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THESIS

STANDARDIZING CONSTRUCTION
BETWEEN INDUSTRY AND GOVERNMENT

by

Nicholas C. Cimorelli

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Thesis Advisor

Paul. M. Carrick

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Standardizing Construction
Between Industry and Government

by

Nicholas C. Cimorelli
Lieutenant, United States Navy, Civil Engineer Corps
B.S., University of Southern California, 1980

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requirements for the degree of

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ABSTRACT

The study set out to determine how standards in construction are developed and whether economic analysis based on life cycle costing is considered during their development. It explains how several organizations in the federal government and in the commercial sector develop standards for construction. It was determined that economic analysis is not used during the development of the vast majority of these standards. Although not used, it is believed that the standards writers could perform economic analysis if they were so inclined. The National Bureau of Standards has actually developed a step by step guide for performing life cycle cost analysis of building codes. It is recommended that the military also develop a similar technique for evaluating changes made to their technical and design related manuals. As a final point, it was concluded that the military is actively involved in coordinating its military specifications with voluntary standards writing organizations in an attempt to eliminate duplication between their standards and is thereby complying with the directive of OMB Circular A-119.

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I. INTRODUCTION

A. GENERAL

This study was undertaken to determine how standards related to construction are developed and to analyze to what extent economic analysis is used during their development. The chapters to follow will make reference in large part to telephone and personal interviews conducted during the course of this study with people involved in this process. Many quotes have been included from these interviews. Individuals interested in this subject may find the quotes interesting and thought provoking since they portray a wide spectrum of views of those involved in the process of developing standards for construction.

Interest in the study was originally generated as a result of an article published in June 1986 by "Standardization News", a magazine sponsored by the American Society for Testing and Materials (ASTM). (ASTM is a primary producer of voluntary product standards.) The article, titled "Communicating Between Code Bodies and Standards Organizations", explained the relationship between the writers of building codes and of product standards. It did not appear from the tone of the article that economic analysis is used during the development of building codes. A portion of the study was therefore devoted to determining how building codes are developed and to what extent, if any, economic analysis was carried out during their development.

Building codes are only a small portion of the total standards used in construction however. There are also product standards, military and federal specifications, guide specifications and an assortment of technical and design related manuals. Therefore, the study also attempted to determine how these various standards were developed and how they related to one another.

Two sources provided direction for the study. The first was OMB Circular A-119 which established conditions for federal participation in voluntary standards work. (Voluntary standards will be explained in Chapter III.) Specifically, the Circular directed the federal government to:

"establish policy to be followed by executive branch agencies working with organizations that produce or coordinate voluntary standards for material, product systems, services or practices and in adopting and using such standards in procurement activities."

The second was a study conducted by the Logistics Management Institute (LMI) titled "Changing the DOD Construction Guide Specifications". The study made three primary recommendations. First, they recommended *against* replacing military construction guide specifications with commercial guide specifications. The second was that the Department of Defense coordinate the development of consolidated guide specifications. The third recommendation was to translate the military guide specifications from existing magnetic media into formats compatible with commonly used word processors. Progress made to date on the OMB and LMI recommendations will be discussed in Chapter IV.

1. Definitions

The following is a list of brief definitions of the standards to be discussed during the course of this study. Each standard will be discussed in detail in the chapters that follow.

- Voluntary standard - describes how to make or perform a product or procedure and is developed by voluntary organizations comprised of manufacturers, users and special interest groups interested in the product or procedure.
- Military or Federal Specification - describes a product or procedure but is developed by the military or federal government.
- Building code - references voluntary standards and tells where and when to use them. Provides minimally acceptable standards to safeguard life or limb, health, property, and public welfare.
- Technical or design related manual - used by the military and federal government. They use building codes for setting their base requirements but increase the minimally acceptable levels where they are considered to be inadequate to satisfy the governments need.
- Guide Specification - federal and commercial guide specifications exist that provide a guide from which to develop project specifications which are contractable documents used to acquire facilities. They reference voluntary standards and military and federal specifications and tell where and when to use them.

B. METHODOLOGY

During the study, specific attempts were made to determine if voluntary product standards were being adopted by the federal government; if military guide specifications were being considered for replacement by commercial guide specifications; if coordination was taking place not only with guide specifications but with voluntary product standards and military and federal specifications as well; and finally to what extent computers and word processors were being used to aid in these processes.

The primary source of information for the study was telephone and personal interviews. This was necessary because the amount of written material that addresses the processes involved in developing standards for construction is very limited and general in nature. A series of questions were developed for use during the interviews. Not all of the questions were asked during each interview since some sources were contacted for the sole purpose of collecting information on a limited area. An interview was considered to be preferable to a questionnaire because the initial interviews served to develop a broad, general knowledge base and subsequent interviews could concentrate on those areas that remained unanswered or that required additional clarification or verification. The following is a list of the questions asked during the interviews.

Research Questions

1. How are building codes, voluntary product standards, military and federal specifications, guide specifications, and technical and design related manuals developed?
2. How was it initially determined that a standard was required?
3. What process is followed in determining the minimum requirement for the various types of standards?
4. Are different procedures followed in developing Government and commercial standards?
5. Is it necessary to have separate Government and commercial standards? Could the Government save time and money by adopting more commercial standards and by doing away with military specifications and standards? Why and under what circumstances would this not be possible?
6. At what level (city, county, state, where in the federal government) are most standards developed? Do the various levels adopt each others standards? Can some duplication of effort be eliminated?
7. Are economic considerations or the benefits received by the consumer considered during the establishment of the various types of standards used in construction? Specifically, is life cycle cost analysis being used by those that determine the level that a standard is written to? Could a user of these standards recognize increases in marginal benefit by increasing the minimally acceptable level of the standard?
8. How do the various standards writing agencies advertise new standards and how do they distribute them once they have been written and approved?
9. To what extent are standards in construction being coordinated in order to avoid duplicity?

10. To what extent are computers and word processors being used to aid in coordinating standards and developing a base of common construction standards?

Information on voluntary product standards was obtained by calling several of the primary developers of product standards such as ASTM and the National Fire Protection Association (NFPA). National organizations that publish building codes were contacted in order to determine how the codes are developed and if economic analysis is used during their development. Several municipalities were contacted in order to determine the effect that building codes have on local governments and also how they are adopted and changed. Primary points of contact in the military were with representatives of the Naval Facilities Engineering Command (NAVFAC), the Army Corp of Engineers (COE) and the Air Force Civil Engineers.

C. ORGANIZATION OF THE STUDY

It was considered important that the organizations that are actively involved in developing standards be described briefly so that the reader will have a better understanding of who is involved in the processes. Chapter II is therefore devoted to introducing the players that are involved in the competitive game of developing standards for construction. Chapter III will describe how the various standards writing bodies go about developing, changing and maintaining their standards. Chapter IV presents the outcomes and findings of the interviews. The general position of the various agencies and their differences of opinion are also presented. The primary differences of opinion regard economics, coordination and duplicity of standards, thus the discussions and any recommendations of how to resolve these disputes are focused around these three areas. The final chapter will review the material and discuss how much progress has been made toward meeting the recommendations made by OMB Circular A-119 and the LMI study.

II. ORGANIZATIONS INVOLVED IN DEVELOPING STANDARDS FOR CONSTRUCTION

A. CONSTRUCTION PRODUCTS AND PROCEDURES

The June 1986 edition of "Standardization News" described standards as follows:

"Standards are basically established for the purpose of defining methods of design, fabrication, or construction, and specifying accepted design procedures; establishing quality requirements and physical properties of materials or manufactured products; and judging structural capabilities, durability, quality, and fire protection capability." [Ref. 1: p.31]

There are thousands of standards that have been developed for the purpose of developing full consensus standards for materials, products, systems, services and procedures dealing with construction related activities. "There are 8000 standards that relate to buildings and construction, 4000 of which are referenced by various building codes and guide specifications." [Ref. 2] These are developed by two main bodies which will be referred to as voluntary and government standards writing organizations.

1. Voluntary Standards Writing Organizations

Voluntary standards are developed by organizations that provide a forum for producers, users, consumers, and special interest groups which include government and academia to meet voluntarily on common ground and develop standards that best meet their needs. Examples of these organizations are the American Society for Testing and Materials (ASTM), Underwriter Laboratories, Inc. (UL), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Institute of Electrical and Electronics Engineers (IEEE), National Electrical Manufacturers Association (NEMA), National Fire Protection Association (NFPA), and the American Institute of Steel Construction, Inc. (AISC). Three organizations will be looked at briefly in order to gain a better understanding of voluntary writing organizations in general.

a. ASTM

The American Society for Testing and Materials (ASTM) describes itself as:

“a developer and publisher of technical information designed to promote the understanding and advancement of technology and to ensure the quality of commodities and services and the safety of products.” [Ref. 3: p. 1]

ASTM develops voluntary full consensus standards for materials, products, systems and services. They are a non- profit, educational association that has been writing standards for over 85 years. An ASTM booklet titled “A Great Value by any Standard” provided the following brief history of ASTM.

“ASTM was founded in 1898 as the American sector of the now defunct International Association of Testing Materials. ASTM became an independent organization in 1902, with committees on steel, non-ferrous metals, cement, and paints.

As the twentieth century progressed, ASTM expanded its scope, but still remained primarily a materials society. In the 1960’s, however, ASTM consciously enlarged its scope to accommodate the development of standards for products, systems, and services. Accordingly, its number of technical committees has grown to 140 and membership, which stood at 175 in 1902, has grown to 30,000, of which 3,700 are international members. These members consist of engineers, designers, business people, industrialists, researchers, administrators and consumers from the private sector, academia, and the government.” [Ref. 4: p. 13]

In addition to developing standards for testing methods and materials, ASTM develops standard specifications, practices, classifications, guides, terminology and standards for such diverse things as emergency medical services, environmental analysis, and waste disposal.

ASTM standard writing committees are divided into seven main categories as follows:

- Ferrous metals
- Nonferrous metals
- Cementitious, Ceramic, Concrete and Masonry Materials
- Miscellaneous Materials
- Miscellaneous subjects
- Materials for Specific Applications
- Corrosion, Deterioration, and Degradation of Materials

When ASTM says that they develop voluntary full consensus standards, they mean that committees are formed consisting of producers, users, consumers and special interest groups that come together on a voluntary basis to develop standards. ASTM has no research or laboratory facilities since research and tests required to develop standards are also performed by volunteers.

Standards are defined as "a rule for an orderly approach to a specific activity, formulated and applied for the benefit and with the cooperation of all concerned." [Ref. 3: p. 1] Full consensus means that ASTM standards are developed through the cooperation of representative elements of the community that have an interest in participating in the development and/or use of the standards. A representative of ASTM had this to say about the consensus process:

"Consensus does not mean that there must be 100% agreement, but a simple majority vote will not satisfy the consensus requirement either. The committees must have as a minimum three interest groups represented. These are manufacturers, users, and special interest groups. The number of representatives on each of these groups present at any single committee meeting may differ, thus, two of the groups must agree on the level of the standard before consensus is achieved. This prevents one interest group, which may comprise a majority of the people on the committee, from determining the level of the standard. Thus, if there are 3 interest groups, at least 2 of them must agree on the level of the standard before consensus is achieved." [Ref. 5]

ASTM believes that by developing full consensus standards, that more technically competent, highly credible standards will result. As a result, ASTM standards are used extensively throughout commercial industry and in the federal, state and municipal governments.

The use of ASTM standards, or any voluntary standards for that matter, is strictly voluntary. They become legally binding only when a government body makes them so or they are referenced in a contract.

ASTM develops six different types of full consensus standards. They are:

- Standard Test Method - a definitive procedure for the identification, measurement, and evaluation of one or more qualities, characteristics, or properties of a material, product, system, or service that produces a test result.
- Standard Specification - a precise statement of a set of requirements to be satisfied by a material, product, system, or service that also indicates the procedures for determining whether each of the requirements is satisfied.
- Standard Practice - a definitive procedure for performing one or more specific operations or functions that does not produce a test result.

- Standard Terminology - a definition or description of terms, or explanation of symbols, abbreviations, or acronyms.
- Standard Guide - offers a series of options or instructions, but does not recommend a specific course of action.
- Standard Classification - a systematic arrangement or division of materials, products, systems, or services into groups based on similar characteristics such as origin, composition, properties, or use.

b. NFPA

The 1987 NFPA directory provided the following overview of NFPA.

"The National Fire Protection Association (NFPA), organized in 1896, has as its mission the safeguarding of man and his environment from destructive fire, using scientific and engineering techniques, and education. The Association was incorporated in 1930 under the laws of the Commonwealth of Massachusetts and has its headquarters in Quincy, Massachusetts.

NFPA is an independent, voluntary membership, non--profit (tax-exempt) organization. A 28-member Board of Directors has general charge of the affairs of the Association, which has a staff of some 130 professional men and women plus more that 140 support personnel.

NFPA is financed principally by sales of its publications and audiovisual materials, membership dues, income from seminars, research grants, and contributions. It operates on an annual budget of \$28 million.

Membership in NFPA totals more than 36,000 individuals and 140 national trade and professional organizations. The vast majority of the members are residents of the United States, many are from Canada, and more than 85 other nations around the globe are represented. Members are drawn from fire departments (27%), health care facilities (17%), business and industry (17%), architects and engineers (7%), fire equipment manufacturers and distributors (4%), educational facilities (4%), trade and professional associations (2%), and other fields (6%).

Activities of NFPA generally fall into two broad, interrelated areas: technical and educational.

The basic technical activity involves development, publication, and dissemination of timely consensus standards intended to minimize the possibility and effects of fire in all aspects of contemporary activity.

In addition, efforts directed at people of all ages and regions continue to educate with regard to preventing the loss of life and property from fire. Key to this educational effort are the teaching of standards and the importance of fire safety as a way of life.

Standards and codes are developed by more than 170 NFPA Technical Committees, each of which represents a balance of affected interests. More than 2,600 individuals serve on the Association's Committees, all on a voluntary,

unpaid basis. Committees are operated according to the detailed official *Regulations Governing Committee Projects* and are administered by the Standards Council which reports to the Association's Board of Directors.

NFPA standards and codes, which currently number about 260, have great influence because they are widely used as the basis of legislation and regulation at all levels of government, from local to national. Many are referenced by agencies of the federal government such as in the regulations of the Occupational Safety and Health Administration (OSHA). The documents also are used by insurance authorities for risk evaluation and premium rating." [Ref. 6]

One of the most well known codes developed by NFPA is the National Electric Code. They also publish the Life Safety Code which outlines the requirements for building exits. In addition, they develop installation standards for items such as sprinklers, fire pumps, and fire extinguishing systems.

c. ANSI

The American National Standards Institute *does not* actually develop standards, but any discussion of organizations involved in standardization would not be complete without mentioning ANSI.

"ANSI is the coordinating organization for America's voluntary national standards system. The ANSI federation consists of 1000 companies, some 30 government agencies, and 250 professional, technical, trade, labor, and consumer organizations. It was founded in 1918 by five of these organizations and three government departments." [Ref. 7: p. 1]

ANSI states in their 1987 Progress Report that they are the:

- Coordinator of the U.S. voluntary standards system.
- Approval organization for American National Standards.
- U.S. member of the International Organization for Standardization and International Electrotechnical Commission.
- Clearinghouse and information center for national and international standards.

Although ANSI does not develop standards, it does provide the means for determining the need for standards and then finds organizations competent to develop the needed standard. Standards writing organizations voluntarily submit their standards to ANSI for recognition as national consensus standards. If the standard was developed in accordance with strict procedures outlined by ANSI calling for such things as balanced committees and consensus among committee members, then the standard can be approved by ANSI and given the label of an "American National Standard".

A vital role filled by ANSI is that of coordinating voluntary standards activities. Besides finding qualified organizations to develop standards, it helps these organizations to avoid duplication of effort and offers a neutral meeting place for resolving differences when they occur.

ASTM and ANSI are the prime sources of voluntary standards for construction in the United States. When a voluntary consensus standard is approved as an American National Standard, ANSI lists it in their catalog of standards which is published annually. In addition, ANSI makes available the latest catalogs and supplements issued by international organizations as the International Electrotechnical Commission (IEC) and more than fifty International Organization for Standardization (ISO) members.

2. Government Standards Writing Organizations

Military specifications (MIL SPEC), Federal Specifications (FED SPEC) and Commercial Item Descriptors (CID) are developed by various government agencies.

A representative from the Navy Civil Engineer Support Office (CESO), a developer of military specifications, had this to say about the development of military and federal specifications:

"MIL SPECS for construction are developed by standards writers within the military. The Navy is unique in this regard in that they have organized a department within the Civil Engineer Support Office (CESO) solely devoted to standards writing. This is unique because in other government organizations, the development of standards for construction is accomplished on a collateral duty basis. At CESO, standards writing is the primary duty of standards writers." [Ref. 8]

FED SPECS are developed by various federal agencies and are controlled by the General Services Administration (GSA). CID's were originally intended to be simplified federal specifications that describe key, salient physical and/or functional characteristics of acceptable commercial products. They were intended to provide a simple means of obtaining materials and products that were commercially available, off the shelf items. Abuse of the CID designator led to the requirement to include additional requirements such as quality assurance statements so that today a CID is nothing more than a "federal specification without a format". [Ref. 9]

Another representative from CESO pointed out that there is a hierarchy of standards as follows:

"There is a hierarchy among the various standards which must be followed within the government. This is partly a result of OMB Circular A-119 which directed that duplication of effort be eliminated wherever possible. Of highest precedence is a multinational treaty organization specification because it is enforced by law. These are rarely encountered unless construction is taking place overseas in a country where such a specification applies. In the normal course of events, a non-government standard, or as it will be referred to from now on, a voluntary standard is to be selected for use if it suits the requirements of the government agency. If one does not exist a CID and then a FED SPEC must be selected. Finally, if no standard exists that suits the military's need, a MIL SPEC may be developed." [Ref. 9]

If the system is working properly, a standard for the same product or procedure should not be duplicated by any two organizations. In some cases, the scope of a specification may differ, in which case two separate specifications would have to be maintained. For example, the Veterans Administration may have a FED SPEC written in a broad scope or general terms. The Army may require a very narrow scope or restrictive specification for the same item, thus it would maintain a separate MIL SPEC. The differences between the various types of specifications and standards will be discussed at length in the next chapter.

a. CESO

The Civil Engineer Support Office (CESO) located in Port Hueneme, California develops military specifications for construction through its Engineering and Design Criteria Department. In addition to developing MIL SPECS, CESO is currently working with 47 different voluntary standards writing organizations. CESO standards writers serve as voluntary members on the standards writing committees of these organizations.

During the first interview performed at CESO it was explained that in the past Congress has been concerned with MIL SPECS and have consequently questioned why there are so many of them and whether they are all necessary. It was explained to Congress that many of the specifications are a result of laws passed by Congress which require the federal government to purchase in accordance with a specification. The Navy can not simply name a product by its brand name or specify a certain manufacturer as is done in industry. It must use a specification which describes the product in terms of its function and end use and what need it must satisfy. In many cases voluntary standards do not deal with end items. In order for the government to be able to adopt them, they must include such things as packaging and preservation

requirements. Just as important from a purchasing standpoint is the amount of the product to be provided. The interviewee used 'friction tape' as an example to illustrate this need. There was a voluntary standard for friction tape that was satisfactory for the military's need except that the width and length of the roll of tape were not standardized. CESO worked with the standards writing committee and managed to have these changes made to the standard. Now the standard can be referenced by purchasing agents in the military which allowed the military to do away with the MIL SPEC for friction tape. This act of coordinating standards will be discussed in part C of this chapter and at length in Chapter IV.

CESO is the initial clearing house for all Naval Facilities Engineering Command (NAVFAC) criteria. They can answer questions or lead you to the people that can answer questions regarding specifications. They are also the primary agent for fixing specifications.

The Engineering and Design Criteria Department at CESO is divided into three divisions called the Vehicular Development Criteria, Facilities Construction, and the Industrial Criteria Development Divisions.

The Vehicular Development Criteria Division develops standards for vehicles and equipment used in the Navy, but primarily for the Naval Construction Battalions. Very few voluntary standards have been developed for these types of items, thus CESO is very active in developing these types of MIL SPECS.

The Facilities Construction Division develops standards used in military construction. They have been able to adopt many voluntary standards because ASTM is very involved in developing these types of standards.

Lastly, the Industrial Criteria Division develops MIL SPECS for such things as Heating, Ventilation, and Air-Conditioning (HVAC) and electrical systems. Here again, there are few voluntary standards in existence to meet the needs of the military, so MIL SPECS must be developed.

A representative of CESO described his department as follows:

"The Engineering and Criteria Development Department of CESO is solely devoted to developing and maintaining MIL SPECS and to working with voluntary standards writing organizations to develop construction standards suitable for adoption by the military. We are unique because this is our primary duty. Most of the other military organizations involved in writing standards are organized to handle programmatic problems such as Engineering or Logistics. People assigned to write a MIL SPEC in these organizations have outside priorities that take precedence over the specification writing effort. These

individuals are not trained to be specification writers. It is a collateral duty for them thus it becomes something unique and out of the ordinary for them. This is not true for the CESO specification writers since writing specifications for construction is their primary duty and something that they have been trained in and do every day. CESO specification writers are versed in the development of standards but not necessarily in the technology surrounding the product or service being standardized. CESO specification writers can gain the technological knowledge they lack through coordination of the standards, by seeking the advice of experts, and by participating on the various standards writing committees.

The commercial sector does not train specification writers, thus there is no resource available to draw from. For this reason, CESO hires young engineers right out of college at the GS-5 level and trains them. They can progress to the GS-12 level and a few GS-13 positions are available. CESO manages to retain about 50% of their specification writers.

The ratio of technicians to engineers has changed considerably over the last 10 years. CESO used to have 2 non-degreed technicians for every engineer. Now there are 3.5 times as many engineers as there are technicians. This change was implemented because it was felt that degreed engineers possessed a broader base of engineering knowledge than a technician who generally specializes in one area. Since the specification writers can be called upon to write a specification in a wide range of areas, the engineer with his broader education, was felt to be better able to write a wider range of specifications." [Ref. 10]

B. BUILDING CODES

Section A described the organizations that develop standards for "construction products and procedures". Building codes describe "where and when" to use these standards in a particular building and they also set minimally acceptable levels for the various product standards. Building codes reference standards and rely on them heavily so that the code will be more understandable and not unduly complicated. For example, a building code may require that steel reinforced concrete be used in a parking structure and that it be able to support 50 psf. The building code would require that the steel reinforced concrete be constructed in accordance with the appropriate product standards for steel and for all the materials that go into making concrete. It would also reference a procedural standard or test standard that describes how to determine the psf rating for the structure. The organizations involved in developing building codes do not develop their own product standards. Rather, they "reference nationally accepted product standards that have been in existence for a long time." [Ref. 11] [Ref. 12] [Ref. 13] [Ref. 14]

This section will describe the voluntary organizations which have been formed for the purpose of developing and maintaining model building codes. An actual description of one of the building codes, the Uniform Building Code, will be presented in Chapter III.

There are three model building codes called the Uniform Building Code (UBC), Standard Building Code (SBC), and the BOCA Building Code (BOCA-BC). The UBC is published by the International Conference of Building Officials (ICBO), the SBC by the Southern Building Code Congress International, Inc. (SBCCI), and the BOCA-BC by the Building Officials Code Administrators International (BOCA). All three of these organizations provide a variety of technical services. Since they compete with one another, generally when one offers a service the others will follow suit and offer a similar if not identical service.

The three building codes are referred to as "model building codes". The information provided by each code is essentially the same although they each have different formats. In addition, the minimally acceptable levels set for the various standards referenced by each may also differ.

Technical services which they all offer are:

- Code Interpretation
- Training and Education
- Plan Review
- Evaluation or Compliance Reports
- Management Consultation
- Training Seminars
- Magazines and Newsletters
- Annual Conferences
- Discounts on model building codes and related publications.

The three model code organizations established another organization called the Council of American Building Officials (CABO), "for the purpose of consolidating their efforts in those matters that are of mutual concern to them". [Ref. 1: p. 32] For example, CABO publishes the codes for 1 & 2 Family Dwellings and for Physically Handicapped Accesses to Buildings. CABO also provides the National Evaluation Service, "which provides manufacturers the option of having their products evaluated, upon submission of one application, for compliance with the requirements of all three of the model building codes". [Ref. 1: p. 32] CABO also provides a forum for the

"Board for the Coordination of Model Codes" (BCMC) which identifies and makes recommendations for the elimination of conflict between the three model building codes, the NFPA Life Safety Code, and other national standards. The intent is not to produce one code through BCMC, but rather "it is hoped that the BCMC process will result in the inclusion of identical concepts in all the codes, thereby facilitating the introduction of new or revised standards into each of the model codes." [Ref. 1: p. 32]

When questioned about the feasibility of having a national building code, a representative of CABO responded as follows:

"It would not be a good idea to have a National Building Code. Presently each of the three regions is operating independently and pride of authorship has kept them separate. Their building codes have different formats but essentially they all have the same content. Having three separate codes has its advantages since the three are always competing with each other to see who can provide the best services. Having a more complete range of services is an obvious benefit to the private sector. These services would possibly be cut back or at least not improved as rapidly if a national building code were adopted." [Ref. 11]

Evidence of this competition between the three model building codes was witnessed as representatives from ICBO, SBCCI, and BOCA were quick to point out that either they were better staffed, provided better services, or were more willing to discuss construction related issues with random callers than were the other organizations.

C. FEDERAL GUIDE SPECS AND DESIGN RELATED MANUALS

Guide specifications and Design Manuals related to naval construction are developed and maintained by the Engineering Field Divisions (EFD's) of the Naval Facilities Engineering Command (NAVFAC). An EFD is responsible for a region of the country or of an overseas region. There are six EFD's whose primary purpose is to provide guidance, direction and assistance to the field activities that are actually contracting to have construction done for the Navy. The EFD's have departments for facilities acquisition, contracting, facilities management, design, and construction.

NAVFAC Guide Specifications (NFGS) are standard documents developed by the EFD's that are used by the field offices to develop project specifications which are then used as contractable documents to procure naval facilities. Design Manuals are guides used by the designer to assist him in laying out the construction project onto drawings. They assist the designer in choosing the correct materials to be used and

procedures to be followed for various types of construction. NAVFAC has five Design Manuals and over 300 Guide specifications related to construction.

Other federal agencies that develop Design Guides and Guide Specifications are the U.S. Department of Energy (DOE), U.S. Army Corp of Engineers (COE), and the National Aeronautics and Space Administration (NASA). DOE publishes the General Design Criteria Manual 6430.1 (GDCM) which is currently being revised by the American Consulting Engineers Council Research and Management Foundation (ACEC-RMF). The COE publishes many design related documents and guide specifications. NASA publishes the Facilities Engineering Handbook 7320.1B and many guide specifications.

There are also two non--government organizations that develop guide specifications. These are the American Institute of Architects Service Corporation (AIA) and the Construction Specifications Institute (CSI). AIA publishes MASTERSPEC and CSI publishes SPECTEXT.

Guide specifications reference voluntary standards, and federal and military specifications and standards. They contain a Products section which specifies the standards with which the various products must comply. An Execution section describes how the products are to be installed and again references the standards that apply.

The EFD's at NAVFAC assume responsibility for maintaining the NFGS. They are apportioned between them in an equitable manner depending upon where the expertise lies.

A representative from the Western Engineering Field Division (WESTDIV) stated that the "Design Manuals take the place of the building codes in the Navy". [Ref. 15] Design Manuals 1 through 5 discuss building construction. The Navy looks at building codes as a document that provides for the "minimum" requirements to provide for a safe facility. The design manuals generally provide the same type of information as the design portion of the building code but where the minimum is not considered adequate for the Navy's use, the minimally acceptable level of the standard is increased.

Design Manuals are, as their name implies, used to design the construction project. This includes laying out the building on drawings. The width of the building or the size of the beams to be used in various areas of the construction project are discussed in the design manual and these requirements are then reflected in the project drawings. [Ref. 10]

The guide specifications are used to develop the project specifications which are contractable documents that describe the quality of the materials used in the contract drawings and how to install them. In this sense, the guide specifications support the design manuals.

In general, Design Manuals are not prepared by anyone in the EFD. Rather, every five years they are updated contracts awarded to Architect and Engineering (A&E) firms. The contract is administered by an architect or engineer (project manager) in the EFD who has been assigned responsibility for maintaining the design manual. There are hundreds of technical or design related manuals but only the first five of the NAVFAC design manuals are used for construction.

D. COORDINATION

Coordination is the act of allowing anyone that is potentially interested in a standard the opportunity to comment on the acceptability of the standard. This is achieved in different ways within industry and government and the level of the standard achieved is not always the same, otherwise there would be no need for separate voluntary standards and federal or military specifications for the same product. (These differences will be discussed in detail in Chapter IV.) Organizations involved in the act of coordinating construction standards are ANSI, CABO, NAVFAC, CESO the Army Corp of Engineers (COE), the National Institute of Building Sciences (NIBS), and the American Consulting Engineers Council Research and Management Foundation (ACEC-RMF). ANSI, CABO, NAVFAC, and CESO have already been discussed. The Army Corp of Engineers is of course the largest military construction outfit in the U.S. They work closely with NAVFAC to identify and eliminate duplication within their guide specifications and design manuals. They perform all of the construction for the Army and approximately 70% of the construction for the Air Force. Like the Navy, they are heavily involved in contracting their work to private contractors and in administering these contracts through field offices.

A representative of NIBS described the organization as:

"a non-profit organization formed by Congress in 1974 to disseminate information and improve criteria in the federal government and the private sector. They have been tasked to study, improve, and harmonize federal criteria and federal agencies are required to work with them in order to achieve that goal." [Ref. 16]

NIBS has been instrumental in developing a data base consisting of Army, Navy, and NASA guide specifications. The data base, consisting of 150,000 pages of typewritten text, has been placed on a Compact Disk Read Only Memory disc (CD-ROM) which will enhance the agencies ability to maintain current documents. It should also be a helpful tool in the coordination effort. This project, known as the Construction Criteria Base (CCB) was initially funded by NAVFAC. The Army and NASA subsequently added their construction related data bases to the CCB. NIBS has plans to add all of the guide specifications and design manuals from all of the federal agencies and ultimately the voluntary standards from industry to the CCB. This fascinating project and its effects on standardization in construction will be discussed in Chapter IV.

ACEC Research and Management Foundation (ACEC-RMF) is in the process of developing a data base that will list all of the standards related to construction that are referenced in the model building codes, the federal agency design guides and specifications, and commercial guide specifications. A representative of ACEC-RMF stated that:

"There are approximately 4000 standards related to construction that are referenced in these codes, manuals, and specifications. The data base is known as the "Building Standards Data Base" and it is hoped that it will be helpful in identifying duplication among standards." [Ref. 2]

The act of coordinating standards documents dealing with construction and the effects that data bases such as the *Construction Criteria Base* and the *Building Standards Data Base* have on coordination will be discussed in depth in Chapter IV.

E. SUMMARY

Standardization of construction products and procedures is achieved through an elaborate network of organizations that develop standards for products and procedures and those that use these standards to develop standard documents that describe where and when to use the standards in a variety of construction projects.

Organizations such as ASTM, NFPA and UL develop the voluntary standards which essentially describe "how to" produce a product or perform a procedure related to construction. ANSI attempts to coordinate the efforts of the standards writing bodies by eliminating duplication of effort and by finding qualified bodies willing to develop needed standards.

GSA, through its network of organizations develops federal specifications. Military Specifications are developed by several branches of the military. NAVFAC's CESO is considered unique in this process of developing military specifications because they actually train full time specification writers whereas other federal agencies develop military specifications on a collateral duty basis.

Three organizations develop model building codes. These are the International Conference of Building Officials (ICBO), Southern Building Code Congress International, Inc. (SBCCI), and the Building Officials and Code Administrators International (BOCA). They publish the Uniform Building Code (UBC), the Standard Building Code (SBC), and the BOCA Building Code respectively. These three organizations established the Council of American Building Officials (CABO) for the purpose of consolidating their efforts in those matters that are of mutual concern to them. CABO publishes the national codes for 1 & 2 Family Dwellings, physically handicapped accesses to buildings, and a Model Energy code. CABO coordinates the activities of the three model code organizations through the Board for the Coordination of Model Codes (BCMC) and the National Evaluation Service.

Federal agencies involved in developing Design manuals and Guide specifications related to construction are the U.S. Department of Energy (DOE), Naval Facilities Engineering Command (NAVFAC), U.S. Army Corp of Engineers (COE) and the National Aeronautics and Space Administration (NASA). DOE publishes the General Design Criteria Manual 6430.1 (GDCM) currently being revised by the American Consulting Engineer Council Research and Management Foundation (ACEC-RMF). NAVFAC publishes 5 design manuals and over 300 guide specifications related to construction. The COE publishes many design manuals and guide specifications as well. NASA publishes the Facilities Engineering Handbook 7320.1B and many guide specifications.

Non government organizations involved in developing guide specifications are the American Institute of Architects Service Corporation (AIA) and the Construction Specifications Institute (CSI). AIA publishes MASTERSPEC and CSI publishes SPECTEXT.

Lastly, organizations involved in coordination are ANSI, CABO, NAVFAC, specifically CESO, COE, the National Institute of Building Sciences (NIBS) and ACEC-RMF. Coordination was defined as the act of allowing anyone that is potentially interested in a standard the opportunity to comment on the acceptability of

the standard. The point was made that the act of coordination performed by the various standard writing bodies does not always result in the same standard. Chapter III will discuss in depth the processes followed by the various standards writing bodies to coordinate their documents with all of the parties that are interested in using the standard.

III. ANALYSIS OF THE STANDARDS USED IN CONSTRUCTION

Now that the organizations involved in developing the standards used in construction have been identified, some of the documents that they actually prepare will be discussed. The documents that will be analyzed are the Uniform Building Code (UBC), several of the voluntary standards, and several of the NAVFAC Guide specifications and Design Manuals. The general form of some of the ASTM standards will be explained. A "standard" connotes code, standard, recommended practice, manual, or guide.

First the processes used by the various standards writing bodies to develop new standards and to change existing standards will be discussed. The process of coordination introduced in Chapter II and its role in each process will also be discussed. A comparison of the Uniform Building Code, NAVFAC guide specifications, and design manuals dealing with Masonry will be presented in order to demonstrate the differences between the three documents. Finally, the process of advertising and distributing the documents will be explained.

A. DEVELOPING VOLUNTARY STANDARDS

Voluntary standards are formed by committees that voluntarily come together to develop standards in an area where a standard can be of benefit to all parties represented on the committee. As the name implies; the standards are voluntary. "They (the standards) are only mandatory when adopted or referenced by a government body." [Ref. 3: p.2] In order for them to receive wide acceptance, they must be developed in such a way that all parties interested in having the standard are given the opportunity to express their opinion regarding the acceptable level that the standard will ultimately establish. This process of coordinating the inputs of all the interested parties results in a "consensus" standard.

ANSI publishes an instruction titled "Procedures for the Development and Coordination of American National Standards." All standards writing organizations that want their standards certified as "American National Standards" must comply with the provisions outlined in this instruction. Many of the standards writing organizations have versions of these requirements outlined in their by-laws. ASTM and NFPA for example, have excellent instructions that fully comply with the ANSI

requirements. Some of the major requirements concern due process and criteria for approval and withdrawal of standards; accreditation of standards developers; planning and coordinating standards; designation, publication, maintenance and interpretation of standards; the appeals process; and the amendments process of the standards.

The ANSI instruction states that "due process means that everyone with a direct and material interest has a right to express a viewpoint and, if dissatisfied, to appeal at any point." [Ref. 17: p. 4]

In order for there to be consensus, the instruction requires that any person "who might reasonably be expected to be, or who indicate that they are, directly and materially affected by the activity in question" be allowed to participate. No single interest group can be allowed to "dominate", thus the committees must be "balanced".

The manual defines "dominance" as a "position or exercise of dominant authority, leadership, or influence by reason of superior leverage, strength, or representation. The requirement implicit in the phrase "without dominance by any single interest" normally will be satisfied by the historical criteria for balance; that is (1) no single interest constitutes more than one third of the membership of a committee dealing with safety or (2) no single interest constitutes a majority of the membership of a committee dealing with product standards". [Ref. 17: p. 4]

As a minimum, the producer, user and general interest groups shall be represented on a committee in order for there to be consensus. NFPA is an example of a standards writing body that requires more detailed subdivisions to be considered. NFPA requires that the following interest groups be represented on its committees:

- **Manufacturer:** A representative of a maker or marketer of a product, assembly or system, or portion thereof, which is affected by the standard.
- **User:** A representative of an entity that is subject to the provisions of the standard or that voluntarily uses the standard.
- **Installer/Maintainer:** A representative of an entity that is in the business of installing or maintaining a product, assembly or system affected by the standard.
- **Labor:** A labor representative or employee concerned with safety in the workplace.
- **Applied Research/Testing Laboratory:** A representative of an independent testing laboratory or independent applied research organization.
- **Enforcing Authority:** A representative of an insurance company, broker, agent, bureau, or inspection agency, or a subsidiary of any of these.

- Consumer: A person who is or represents the ultimate purchaser of a product, system or service affected by the standard, but who is not included in the User category.
- Special Expert: A person not representing any of the other categories, and who has special expertise in the scope of the standard or portion thereof.

As explained in Chapter I, consensus is achieved when at least two-thirds of the interest groups agree on the level of the standard. A simple majority of committee members will not satisfy the consensus requirement. A requirement of all standards is that they be reduced to writing and be made available to any interested party.

There must be an Appeals mechanism that is "identifiable, realistic, and readily available for the impartial handling of substantive and procedural complaints regarding any action or inaction". [Ref. 17: p. 5]

Proposals for new standards and proposals to revise, reaffirm, or withdraw approval of existing standards must be given prompt attention. They must be transmitted to ANSI for listing in an ANSI publication called "Standards Action" in order to provide an opportunity for public comment.

The committees are required to make a "concerted effort to resolve all expressed objections and to advise each objector of the disposition of the objection and the reasons therefor". [Ref. 17: p. 5]

The ANSI manual requires that all members of a consensus standard developing group be given the opportunity to respond, reaffirm or change their vote regarding unresolved objections or any substantive changes to the standard they are developing.

A variety of records must be maintained that permit an overall view of what actions took place during the development of the standard. As a minimum, such records should include:

- Draft standards
- Proposed amendments
- Ballot results
- Disposition of objections
- Rationale or principle supporting data as appropriate to the development of new standards and revisions of existing standards.

The ANSI instruction goes on to list the criteria for Approval and Withdrawal of American National Standards. In order for a standard to be approved as an American National Standard, it must meet the requirements of due process, consensus, and the other criteria mentioned.

The ANSI instruction considers consensus to be achieved when:

"substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution." [Ref. 17: p. 5]

ANSI has delegated the responsibility of determining if consensus has been achieved to the Board of Standards Review (BSR).

The BSR considers whether the following criteria have been satisfied when deciding whether to accept proposals from standard writing organizations to approve, revise or reaffirm their standards as American National Standards:

- Due process requirements were met.
- Consensus was achieved.
- The standard is within the field previously registered with ANSI.
- Any identified significant conflict with another American National Standard was resolved.
- Other known national standards were examined with regard to harmonization and duplication of content.
- The proposed American National Standard was provided to the administrator(s) of the appropriate USA Technical Advisory Group(s).
- Any appeal to the standard developer was completed.
- ANSI's patent policy is met if applicable.

The manual goes on to state the following:

"The BSR shall consider any evidence provided to it that the proposed American National Standard is contrary to the public interest, contains unfair provisions, is unsuitable for national use, or is technically inadequate.

The BSR shall not approve standards that duplicate existing or proposed American National Standards unless there is a compelling need." [Ref. 17: p. 6]

The instruction goes on to discuss reasons for withdrawing standard such as not meeting the consensus requirement or violating some other criteria. The instruction then describes the areas that a standards writing organization must agree to satisfy in order for them to be accredited as an American National Standards developer. For example, they must agree to conform to proper due process requirements, provide for adequate administrative oversight and maintenance of the standards and agree to work with ANSI in standards planning and coordination activities that are of mutual interest.

The instruction devotes an entire section to planning and coordinating American National Standards which is of course a primary objective of ANSI. The purpose of planning and coordinating the standards developers is to "identify national standards needs and to generate joint plans for providing American National Standards to meet those needs." [Ref. 17: p. 8] ANSI states that their attempt is to:

"Identify and assess resources available for the development of needed standards; establish priorities; generate voluntary, coordinated plans for standards development, minimize unnecessary duplication; avoid the promulgation of conflicting standards; and assure the opportunity for participation by all directly and materially affected interests." [Ref. 17: p. 8]

ANSI requires that a standard approved by them have its cover marked with an approved logo with the words "American National Standard". The standards developer agrees to publish the standard and make it available within six months after it has been approved as American National Standards. "The standards developer shall publish the standard or shall grant the right of publication to ANSI." [Ref. 17: p. 10] This is an interesting statement because many of the standards developers hesitated to publish their standards through ANSI because much of their income is generated from the sales of their standards. ASTM in particular was especially vocal in this regard. However, it was interesting to note that in the 1986 Catalog of American National Standards that large standards developers, to include ASTM and NFPA, are listed as organizations using the American National Standard logo. In ASTM's case, only selective ASTM standards have been adopted as American National Standards. The catalog lists 399 ASTM standards which deal primarily with petroleum products, fuels, gases, oil products and related materials. This represents a very small portion of the 7000 standards that ASTM publishes. In fact, the entire ANSI catalog only lists approximately 7200 standards which again is only a fraction of the total number of consensus standards that are developed. It would be interesting to determine the percentage of standards that each standards developer publishes through ANSI and the percentage that they choose to develop themselves. Charles D. Sullivan noted in his book "Standards and Standardization" that "As of 1983, ANSI was not yet officially recognized as the 'Clearing house' for standards." [Ref. 18] It would appear that this is still the case today based on the relatively small number of standards listed as American National Standards in relation to the total number of consensus standards developed.

The ANSI instruction concludes by explaining in more detail the appeals and amendments process.

Whether or not a standards writing body decides to publish their standard through ANSI, if they are in the business of developing consensus standards they have by-laws which govern their activities which are similar to the ones developed by ANSI. Having the American National Standard logo a standard lets everyone know that the standard is a consensus standard, thus there is some benefit in having the standard approved by ANSI.

A representative of CABO was questioned regarding whether the standards developers had access to the information that would be necessary for them to make intelligent decisions. He presumed that they did since they are required to give rational explanations for their decisions. He cited the recent change to the plumbing standard that apparently has a stack of papers 5 inches high in support of the change. He stated that if proponents of a change have done their homework and if an expert is at the meetings to answer questions for the committee regarding the change, then the committees will have access to the proper information and be able to make more intelligent decisions. [Ref. 11] These statements merely reinforce the importance of coordination which is the key to developing a consensus standard.

There are other standards developers that develop voluntary standards that can not be considered consensus standards because they are developed solely by manufacturers or trade organizations. Some of these are excellent standards but because they did not allow users or special interest groups to comment on the acceptability of these standards they cannot be considered consensus standards. ANSI serves a vital role regarding these standards because they can turn a trade standard into a consensus standard by coordinating the standard through users and special interest groups and thereby achieve consensus. [Ref. 10]

B. DEVELOPING MILITARY AND FEDERAL SPECIFICATIONS

Chapter II pointed out that most government agencies involved in writing military or federal specifications, hereafter referred to as MIL SPECS or FED SPECS, do so on a collateral duty basis. The Engineering and Design Criteria Department of the Civil Engineer Support Office (CESO), was described as an organization in NAVFAC that is dedicated to the development of standards related to construction. CESO provided two guidelines that they use when preparing a new specification or standard and when revising specification or standard. These guidelines are considered

to be representative of the general procedures followed by most government agencies when developing standards. Thus, just as the ANSI procedures were used to describe voluntary standards developers activities, the CESO guidelines will be used to do the same for developers of MIL/FED SPECS.

1. Preparing a New Specification or Standard

The document used by CESO to prepare a new specification or standard is numbered 1503b/0207b Topic I and is dated 16 SEP 1981. It lists nine steps as follows:

1. Receive requirements.
2. Investigation.
3. Project Initiation
4. Commercial Availability.
5. Commercial Availability Analysis.
6. Prepare First Draft.
7. Circulate.
8. Comments - resolve/incorporate.
9. Prepare Final Draft Package.

CESO can not develop a specification on its own. They must have someone approach them with a request to develop a specification to satisfy a requirement. Receiving these requirements is the first step in preparing a new specification or standard.

The second step is the investigation. An extensive search must be initiated "for an existing document which will satisfy the given requirements". [Ref. 19: p. 1] If an existing document exists that satisfies the requirement, then a new document will not have to be prepared. If minor adjustments can be made to an existing document, an attempt will be made to incorporate them into the existing document by "submitting them as essential comments with justification to the Preparing Activity". [Ref. 19: p. 1]

Assuming that a suitable document does not exist a project will be initiated which is step 3. A number will be assigned to the project and a project folder will be made.

At this point, the reader is reminded that the whole reason for developing a specification is so that there will be a document available that, when referred to in a purchasing situation, will provide a product that meets the requirement of the user. With this in mind, the fourth step is to ask commercial manufacturers if they currently have products that will satisfy the requirement.

Step 5 involves analyzing the comments received from the manufacturers "to determine if the requirements can be met by currently available products". [Ref. 19: p. 3] If commercially available items are available, a first draft of the specification is prepared. If not, the activity requiring the specification is requested to either adjust its requirements to meet the specification of commercially available items or if the requirements are inflexible the specification developer proceeds with developing a first draft.

Preparing a first draft of the specification is the sixth step. The specifications developer is required to prepare the draft in accordance with Military Standard 961B dated 31 MAY 1985, which is a guideline for preparing military specifications and standards.

The specification is written in a 6 section format. The first section describes the scope of the specification. The second section lists the reference documents used in the body of the specification. Section 3 is the Requirements section which lists the standards that the product must comply with. Section 4 describes Quality Assurance and Testing requirements. Section 5 lists Preservation and Packaging requirements. Section 6 is called the Notes section and is used to give special instructions or information to contracting officer. It may also expand upon or highlight various options available regarding the product. [Ref. 20]

Once the draft is completed, Step 7 requires that the draft specification be circulated to interested government activities, potential suppliers, and affected industry associations. A representative of CESO had this to say about the coordination of MIL SPECS:

"In that industry responses are solicited, MIL SPECS can be considered to be consensus standards to a degree. DOD must however determine its requirements and its needs and match industry capability with that requirement. The requirement will not be reduced to satisfy a portion of industry, thus MIL SPECS differ from voluntary standards in a very significant way. Coordination is still a very key factor in this development. As a result of coordination, industry will in some cases be able to demonstrate that new technological developments will better satisfy the requirement. When this happens, the requirement can be amended to reflect industry's constructive input. Possible users in DOD who may use the product or who are using related products are also contacted. This coordination allows the reviewers to examine and criticize what is being done and how it is being done before the specification is ever used in a contract." [Ref. 9]

During the eighth step, the comments received by the reviewers are resolved and incorporated as appropriate. Letters are sent to the reviewers informing them of how their comments were used. Most of the standards writing bodies recognize the importance of this but because so many of them do it on a collateral duty basis, this important step is largely neglected. CESO, on the other hand, considers this to be a professional courtesy and requires their specification writers to send a response letter to the reviewers so that they will be more inclined to comment the next time they are requested to review a specification.

During the final step, the final draft package is prepared. The sections are checked against one another to insure that applicable documents are included by reference and that referenced paragraphs cross check one another. The document is checked against custodian, reviewer and user comments to insure that their interests have been addressed. Any errors discovered during the review are corrected. The completed package is forwarded to agencies on the final circulation list.

2. Revising a Specification or Standard

The steps involved in revising a specification are basically the same with a few minor exceptions. First of all, a specification is required to be revised at least every 5 years. It takes approximately one year to either write a new specification or revise an existing one. The revision process begins by assigning a specification writer as the maintainer of the specification during its life cycle. The project folder developed during the development of the specification is used to collect comments received from users of the specification. If many comments are received that warrant immediate attention, the specification may be revised as often as required. In some cases an existing specification may not reflect a significant advance in technology. If an acquisition is scheduled that requires a specification that reflects the advanced technology, the specification may be amended on the spot so that the acquisition can take place. The specification would then be coordinated with other users to insure that it meets all their needs. In normal cases though, the five year cycle is adequate and comments received are filed in the project folder and addressed when the time comes to revise the standard.

During the investigation step of the process, the specification writer will verify that there is still a need for the document. Once this is done, the process for revising the document is essentially the same as the process used to develop a new specification.

3. Federal Specifications and Commercial Item Descriptions

FED SPECS and CID's take precedence over MIL SPECS. They are controlled by GSA. A representative of CESO stated that a CID was:

"originally intended to be a simple means of identifying materials and products that were commercially available off the shelf items. Abuse of the CID designator led to the requirement to include quality assurance statements and other requirements to the point that today a CID is more like a FED SPEC without a format." [Ref. 9]

It was not determined how FED SPECS or CID's are actually developed or revised but it is assumed that the procedures are basically the same as those followed by CESO. Basically, all government specification writers must abide by the direction given in OMB Circular A-119 and follow the hierarchy of standards to see if there is already a standard in existence that will suit their need. That is, if a voluntary standard exists that doesn't quite meet the need, an effort should be put forth to have it amended so that it will meet the need. In some cases, a FED SPEC writer may discover a MIL SPEC that suits his needs in which case he can adopt it and move it up in the hierarchy by adopting it as a FED SPEC. This process of coordination is a requirement of all government specification writers.

4. An Illustration of the Hierarchy of Standards

A representative of CESO used the example of a chain link fence to illustrate how a standard can move from a MIL SPEC to a FED SPEC to a voluntary standard. At particular Naval activity, 10 miles of chain link fence around a secure activity had to be replaced because it was so light that the wind moved it to such a degree that it set off the motion detector alarms of the security system. The contractor that installed the fence had satisfied the diameter requirements for chain link specified in the contract by purchasing chain link with a plastic covering. Thus, the fence was not as heavy as anticipated and moved excessively when the wind blew.

As is their practice, CESO requested industry to write a suitable standard for chain link fence. Industry said that they were unable to, thus CESO began writing a MIL SPEC for chain link fence. GSA became involved and determined that they also needed this specification so the MIL SPEC was upgraded to FED SPEC. CESO retained responsibility for developing the specification but it would be published as a FED SPEC. The specification lasted about one year but was revised when extensive user and industry complaints were received. The comments narrowed after the revision

and there have been no comments received after the second revision was completed. Steps are underway to have ASTM adopt the standard as a voluntary standard which is exactly what the Navy wanted in the first place.

This is just one example of how the government interacts with industry to develop needed standards. Since voluntary standards take precedence over government standards if they are acceptable, ideally the government would like industry to develop all of their standards. This is of course not possible because the military is involved in activities that industry will never be involved in. Thus industry can not be expected to develop these standards for the government. However, OMB Circular A-119 requires that voluntary standards be adopted wherever possible. "The Navy relies heavily on CESO to perform this act for them." [Ref. 10] Virtually every specification writer at CESO is involved on at least one and most are on two voluntary standards developing committees. Their goal is to identify voluntary standards that can replace MIL SPECS. Once they are seated on a committee they attempt to demonstrate how the standard fails to meet the needs of the government. As a special interest representative, CESO's comments must be considered in order to develop a consensus standard. CESO is currently working with 47 different voluntary standard developers.

A representative from CESO indicated that the most common complaint by government representatives regarding voluntary standards is that they don't deal with end items.

"In particular, many voluntary standards do not address packaging requirements. The military has different packaging requirements depending on where the item is to be shipped. Once the voluntary standards writers incorporated these packaging requirements into the the voluntary standard the standard could be adopted by the government." [Ref. 9]

CESO is trying to get the standards writing organizations to develop their standards to the point where they can be used as acquisition standards.

The Navy is not trying to impose government requirements on the commercial world but rather is attempting to get the standards developers to think about the end user a little more. As long as the voluntary standards developers do not develop standards that can be used as acquisition standards, CESO and other government standards developers must continue to develop their own standards that address the needs of the end user and not just the manufacturer. [Ref. 21]

5. Other Government Standards

NAVFAC has a publication titled "Engineering and Design Criteria for Navy Facilities". NAVFAC refers to it as NAVFAC P-34. It lists all the different standards that are used as references for naval facilities. Besides the MIL/FED SPECS, NAVFAC Guide specifications, Design Manuals, and voluntary standards already mentioned, there are standard specifications, standard drawings, Federal Construction Guide Specifications, DOD Guide Specifications for Military Family Housing, Military Standards, Military Handbooks, Military Sheet Form Standards, Federal Test Methods, and Special U.S. Government specifications and standards. All of these can be considered as standards that are used in military building construction.

6. Summary

In order to clarify the differences between some of the government standards a representative of CESO provided the following summary of the standards:

"Military specifications are for procurable items and their development is guided by MIL SPEC Publication 961. Military Standards and Handbooks are "how to" type publications that describe testing procedures and provide informational guidance. Their development is guided by Military Standard 962A. Guide specifications describe how to install products in a construction project. NAVFAC Design Manuals provide policy guidance and direction for a specific area. They are in the process of being converted into military handbooks." [Ref. 20]

The procedures involved in developing and revising military and federal specifications were discussed. Coordination was shown to be a key element in this process. Although not mentioned previously, the Defense Standardization Manual DOD 4120.3-M provides general policy and guidance for coordinating standards with industry. Lastly, the hierarchy of standards and efforts involved by government in adopting voluntary standards were discussed.

C. BUILDING CODES

A pamphlet published by BOCA provided the following description of building codes:

"Practically, a building code is the government's official statement on building safety. Technically, it is a compendium of laws and ordinances setting minimum safety standards and arranged in a systematic manner (codified) for easy reference. It embraces all aspects of the building construction - fire and structural items as well as plumbing, electrical, and mechanical systems." [Ref. 22]

It was stated previously that although the three model building codes have different formats, they contain essentially the same information. For this reason, only one of the codes will be discussed in order to describe the areas that are covered in a building code.

1. Uniform Building Code

The Uniform Building Code (UBC) published by the International Conference of Building Officials (ICBO), references Uniform Building Code standards which are standards adopted from the various standards writing organizations such as ASTM, NFPA, Federal Specifications, and standards recognized by ANSI. The UBC states that:

"The purpose of the building code is to provide minimum standards to safeguard life or limb, health, property and public welfare by regulating and controlling the design, construction, quality of materials, use and occupancy, location and controlling the design, construction, quality of materials, use and occupancy, location, and maintenance of all buildings and structures within a jurisdiction and certain equipment specifically regulated therein."

The building codes are designed to be used by municipalities. Once adopted through local ordinances they have the effect of law. The building officials are responsible for enforcing the building code and any amendments made to it by the local government.

The UBC is broken up into eleven parts consisting of 60 chapters and an appendix which supplements some of the chapters.

- Part I - deals with administration requirements as organization and enforcement, permits and inspections and describes the title, scope and general purpose and application of the code.
- Part II - definitions and abbreviations.
- Part III - lists requirements for seven basic types of occupancies.
- Part IV - lists requirements based on types of construction and discussed five types of buildings.
- Part V - lists the engineering regulations for quality and design of the Materials of Construction as general design requirements and specifically for masonry, wood, concrete, steel, and aluminum.
- Part VI - lists detailed regulations for excavations, foundations, and retaining walls, veneer, roof construction and covering, exits, skylights, sound transmission control, penthouses and roof structures, masonry or concrete chimneys, fireplaces and barbecues, fire extinguishing systems, stages and platforms, and motion picture projection rooms.

- Part VII - lists the fire resistive standards for Fire Protection.
- Part VIII - lists regulations for use of public streets and projections over public property.
- Part IX - covers walls and ceiling coverings.
- Part X - addresses special projects, specifically cellulose nitrate, prefabricated construction, elevators, dumbwaiters, escalators and moving walks, light-transmitting plastics, glues, and glazing.
- Part XI - lists the UBC standards referenced in the code by title and source and in which chapter and section they are referenced.
- Appendix - gives life safety requirements for existing high rise buildings and existing buildings other than high rise buildings. It also addresses covered mall buildings, aviation control towers, agricultural buildings, requirements for Group R, Division 3 Occupancies, alternate snow load designs, earthquake recording instrumentation, re-roofing, sound transmission control, basement pipe inlets, patio covers, elevators, dumbwaiters, escalators, and moving walks, energy conservation in new building construction, regulations governing fallout shelters, and excavation and grading.

The *energy conservation in new building construction* section (Chapter 53) refers the reader to the CABO Model Energy code which sets forth the minimum requirements for effective use of energy in the design of new buildings and structures additions to existing buildings. It is based on ASHRAE standard 90A-1980 and was originally developed jointly by ICBO, BOCA, SBCCI and the National Conference of States on Building Codes and Standards under a contract funded by the U.S. Department of Energy. The code is now maintained by CABO and is adopted by reference in the UBC.

A building or structure is deemed unsafe if it is structurally unsafe or not provided with adequate egress, a fire hazard, or otherwise dangerous to human life. Use of a building or structure that is inadequately maintained, dilapidated, suffering from obsolescence, a fire hazard, damaged due to a disaster, or otherwise damaged or abandoned, is considered an unsafe use. Parapet walls, cornices, spires, towers, tanks, statuary and other appendages or structural members which are supported by, attached to, or a part of a building and which are in deteriorated condition or otherwise unable to sustain the design loads specified by the code are designated as unsafe building appendages. [Ref. 23]

In general, the building code specifies where and under what circumstances a standard is to be applied. Part XI of the code lists all the standards referenced in the code by title and source. Reference to the standard, rather than incorporation of the entire standard document into the code, makes the codes easier to read and apply.

Buildings are broken down into classes of buildings depending on their use or occupancy and general requirements for all occupancies are listed in the code. Requirements such as minimum separation distances between buildings, fire ratings for occupancy separations, and location of the building on the property are listed. Allowable floor areas and maximum height for the various classes of building are also listed. General requirements such as pedestrian walkways, sanitation, and access to toilets and other facilities are listed.

Occupancies are listed as Group A,B,E,H,I,M, or R, each of which describe a building in terms of its use and occupancy. For example, Group A applies to any assembly building with a stage and an occupant load of 1000 or more in the building. An assembly building or portion of a building used for the gathering of 50 or more persons for such purposes as deliberation, education, instruction, worship, entertainment, amusement, drinking, or dining or awaiting transportation. Occupant load refers to the live load superimposed by the use and occupancy of the building not including wind load, earthquake load or dead load which is the vertical load due to the weight of all permanent structural and non-structural components of a building, such as walls, floors, roofs, and fixed service equipment. There are four other divisions listed under Group A Occupancies which have various occupant loads both with and without a stage. Another example is a Group I occupancy which describes nurseries, hospitals, nursing homes, and jails.

It is interesting to note that the UBC does not list the requirements for single homes. There is a separate code for these maintained by CABO called the CABO One and Two Family Dwelling Code. This code is jointly sponsored by ICBO, BOCA and SBCCI. It eliminates conflicts and duplications among the model codes to achieve national uniformity and covers mechanical and plumbing requirements as well as construction and occupancy for one and two family dwellings.

Part IV of the code lists five types of buildings.

- Type I - the most detailed and most fire resistive type of building. It requires that the structural elements be steel, iron, concrete or masonry. The majority of the materials used are non-combustible.
- Type II - Buildings are constructed primarily of non-combustible material however more fire retardant treated wood is permitted.
- Type III - Exterior walls have to be non-combustible.
- Type IV - Buildings are allowed to use material other than concrete, iron, steel, or wood in the permanent partitions and members of the structural frame

provided they have a fire resistance of not less than one hour. Exterior walls shall still be constructed of non-combustible materials.

- Type V - Buildings may be of any materials allowed by the code so long as the construction provides one hour fire resistance throughout.

There are also separate codes for mechanical, plumbing, fire prevention, electricity, plus many others dealing with a variety of subjects. The Uniform Mechanical Code, as an example, contains requirements for the installation and maintenance of heating, ventilating, cooling and refrigeration systems and is sponsored jointly by ICBO and the International Association of Plumbing and Mechanical Officials (IAPMO). It provides minimum standards to safeguard life or limb, health, property, and public welfare. Another example is the Uniform Plumbing Code which is published by IAPMO and covers all aspects of plumbing, including requirements for plumbing materials and IAPMO installation standards. It is endorsed by ICBO as a companion document to ICBO's model codes and is available from either organization. [Ref. 23]

The Uniform Building Code provides the following description of the Uniform Fire Code and the National Electric Code:

"The Uniform Fire Code sets out provisions necessary for fire prevention while achieving uniformity in terms and requirements with other codes published by ICBO. It is sponsored jointly by the Western Fire Chiefs Association and ICBO. The UFC standards are a companion publication of the UFC which contains standards of ASTM and NFPA referenced by the Uniform Fire Code.

The National Electrical Code is the electrical code for most states, counties, and cities in the U.S. and is used by electricians, electrical inspectors, electrical equipment manufacturers, architects, builders, consulting engineers, contractors, fire marshalls, fire chiefs, building inspectors and anyone who must specify or certify electrical installations." [Ref. 23]

As mentioned before, there are also separate codes maintained by CABO for One and Two Family Dwellings and for the Model Energy Code.

2. Purpose of a Building Code

BOCA provided the following description for the purpose of a building code:

"Any community seeking orderly growth and development, regardless of size, must enact and effectively administer reasonable regulations for minimum standards of health, safety, and welfare in the homes of its inhabitants as well as in its industrial, commercial and other structures. Such regulations are embodied in local law as codes and ordinances and are enforce through police powers vested in the community by the state. Code standards and requirements

represent a base below which no property in the community will be allowed to go, as well as a starting point from which higher standards of liveability and marketability may be developed for use in related programs of community growth.

A comprehensive system of modern, up-to-date codes and coordinated enforcement are essential elements of any effort to prevent, arrest, and eliminate devastating fire losses, building structural distress and deterioration. Codes in themselves will not rid a community of these problems. However, they are potent and effective preventive tools, and when used in combination with other local actions, can make a major contribution to the community's objectives." [Ref. 24: p. 1]

Model codes address basic aspects of public safety in the built environment, such as:

- Structural Safety - to assure that a building or its parts will not collapse from the anticipated loads and demands of use, soil conditions, winds, storms, extremes of temperature, flood, earthquakes, rot, rust, decay and destructive insects.
- Fire Safety - to prevent or reduce fire hazards by controlling the type and use of materials, electrical wiring, and heating facilities, as well as to allow sufficient time for people to escape from a building and to prevent destruction of it and adjoining property by spread of conflagration.
- Facilities for Public Health - basic requirements for personal sanitation, a healthful interior environment and clean surrounding, as well as facilities for waste disposal which prevent pollution and the development and spread of disease.
- Orderly Community Development and Well Being - prudently managed growth to make sure that land development does not lead to congestion, deficiencies in essential services and facilities, and the accelerated deterioration of property due to neglect and misuse. [Ref. 24: p. 1]

3. Changes to a Building Code

A building code is not a consensus document in the same sense that product standards are. Changes are made to it by a select group called "building officials" who are employees of a city or municipality responsible for enforcing the building code.

Anyone may submit a change proposal to a building code. This is done by sending a written request the governing model code organization. In the western U.S. this would be ICBO, in the North and Northeast, BOCA, and in the South and Southeast, SBCCI. A county building official from Monterey county in California provided the following explanation of how the code is amended:

Proposed code changes are assigned to a code development committee. Class A members, consisting of county and city building officials located within the jurisdictions that will be affected by the code change, vote during a code change session to determine if a change will be adopted.” [Ref. 25]

An employee from ICBO provided additional insight into the procedure as follows:

“Changes may be approved, disapproved, approved as revised, or held for further study. Decisions are based on consensus among the building officials representing the various municipalities. Code changes resulting from the committee meetings are distributed publicly and anyone may challenge the decision of a change.” [Ref. 26]

A senior engineer on the SBCCI staff explained the process as follows:

“Anyone can submit a change to the code. This change request is assigned to a committee for action where it is considered and testimony regarding the change is taken. The change is then reviewed at the Annual Convention and a vote is made. A final decision is withheld however until a tally is made of all the ballots returned by the building officials that were unable to attend the annual convention. A blue book of the proposed changes is distributed and made available to the public for review and comment and a red book containing the final decisions of the building officials is distributed so that the various municipalities can update their codes.” [Ref. 13]

A representative of CABO was questioned concerning representation on the building code committees and specifically whether all interest groups are adequately represented. He pointed out that the building officials do not necessarily have the expertise necessary to analyze all of the changes. For this reason, sub-committees are formed wherein the expertise is rounded out. As an example, CABO has a 15 person committee on the One and Two Family Dwellings code represented by the following interest groups:

- Model Codes (6; 2 from each)
- State (1)
- Federal (1)
- Consumer (Homeowners Warranty) (1)
- Research and Testing (1)
- Engineering and Architecture (2)
- Homebuilder (1)
- Modular Manufacturer (1)

- Labor Unions (1)

The wide distribution of interest groups seems to indicate that most interest groups are represented on this particular committee. Committees such as this one analyze the proposed changes to the building codes and make their recommendations to the building officials. In this way, the building officials can make a better informed, more intelligent decision regarding adoption of proposed changes to the code.

The building codes are completely updated every three years and amendments are issued annually. Prior to a National Convention of a model code organization, everyone involved in the organization receives notification of national level interest items and state related items that are to be considered at the convention. This give the building officials sufficient time to prepare questions for the sub-committees that they need answered before they can vote on the proposed amendments. [Ref. 11]

4. Code Adoption and Changes to Local Codes

Most towns, cities and municipalities lack the nationwide resources for technical research, testing and evaluation which are required in order to draft a sound building code which are available to the three model code organization. It is easier for them to adopt one of the model documents published by either ICBO, BOCA, or SBCCI. This is done by the incorporation of the code by reference in an adopting ordinance rather than reprinting the document at length.

A senior plans examiner at ICBO indicated that most of the municipalities in the western part of the U.S. simply adopted the Uniform Building Code. San Francisco is an exception in that they maintain their own building code. In addition, he pointed out that just because a city adopts the model code doesn't mean that they can't amend it. The state of Oregon, for example, has adopted the UBC but they also have an amendment section large as the code itself.

In order to develop a better understanding of this process, several building officials in Monterey county, California were contacted and asked to address this issue. All of the municipalities in the county had adopted the UBC under local ordinances. One building official indicated that there was a Planning Commission that reviews designs and provides input to the city council who ultimately decide what portions of the code will be adopted or amended. [Ref. 27]

The municipalities have no direct relation with the county and the state except that the latter two may impose requirements on the others, in which case the municipalities are forced to adopt these requirements into their local building code. In

Monterey County, the building officials meet once a month to discuss issues or problems that affect them all and attempt to resolve them. [Ref. 28]

A municipality may have to make a change to the code before it can be adopted because of the way the city is laid out, for example, or the type of construction used in an area may be unique or special fire protection measures must be considered that are not addressed in the code. A building official from Monterey County had this to say about these unique change requests:

"In some cases, a municipality may be more strict than the UBC while in other cases a less strict version of the code may be adopted. In this latter case, a municipality must first have a findings performed by the state before a less strict version of the code can be adopted. This involves presenting the proposed changes to the state and explaining and justifying why a less strict version of the code would be suitable. In many cases, in order to justify a less strict standard in one area, a municipality will have to make up for this perceived deficiency in another area." [Ref. 27]

A professor at the Naval Postgraduate School in Monterey California, who served as a council member in 1983 for one of the local municipalities explained that proposed amendments to the code would be submitted to the city council by the building and planning department. He stated that:

"The council would review these proposals and vote whether or not to incorporate them into the code. Technical evaluations of the proposals were performed by the city technical staff and outside consultants. The city council received the proposed amendment in writing worded exactly as it would appear in the code. An oral technical presentation would be made to explain why the change was required and what it meant." [Ref. 29]

D. GUIDE SPECIFICATIONS

1. Description of Guide Specifications

In a study conducted by the Logistics Management Institute (LMI) for DOD, Construction Guide Specifications were defined as "the primary reference documents used by designers in preparing the descriptions of technical requirements of individual construction projects". [Ref. 30: p. ii] The U.S. Army Corp of Engineers (COE) and the Naval Facilities Engineering Command (NAVFAC) are the primary agencies involved in major construction projects in the Department of Defense (DOD). Both organizations have construction guide specifications which they use to prepare project specifications for individual construction projects.

"Project specifications serve a twofold purpose: during the bidding phase, they communicate the quality level in materials and workmanship that is required, and during the construction phase, they provide the contractual means for monitoring contractor's adherence to project requirements. Guide specifications and project specifications should not be confused with FED/MIL SPECS, which are detailed descriptions of construction materials prepared by the Federal Government and the DOD, respectively. FED and MIL SPECS are often referenced in DOD guide specifications but are not used to directly specify construction materials or processes." [Ref. 30: p. 1-1]

The LMI study went on to explain that the private sector also has construction specifications. These are MASTERSPEC, which is produced by the American Institute of Architects (AIA) Service Corporation, and SPECTEXT, which is produced by the Construction Sciences Research Foundation under the auspices of the Construction Specifications Institute (CSI). The General Services Administration (GSA) has adopted and modified MASTERSPEC for their construction projects.

The LMI study explained that all major guide specifications reference national reference standards to efficiently communicate material and construction requirements. ASTM and ANSI are the leading industry sources of these reference standards. The military construction guide specifications also reference MIL/FED SPECS dealing with construction. [Ref. 30: p. A-7]

The COE and NAVFAC develop and maintain separate construction guide specifications although some of these are joint service guide specifications. The Army is currently using approximately 20 NAVFAC guide specifications and the Navy is using approximately 60 Army guide specifications. In all cases, the Army or Navy place a cover sheet over the others guide specification and refer to it as their own from then on. At present, it is impossible to tell who originated the document but steps are currently underway to give appropriate credit to originators of guide specifications adopted for use by other services by placing the name of the originator on the cover of the document. [Ref. 31]

The LMI study provided the following synopsis of how COE Guide Specifications are developed:

"The COE develops, distributes, and maintains all of its specifications through the Huntsville Alabama Division. That division writes some guide specifications but most are produced by other sources, with the Huntsville division providing coordination and quality assurance. Various COE districts and laboratories write specifications in a particular area when they are recognized leaders in that area. In many cases, contractors assist with specification updating and writing when COE staff resources are not available." [Ref. 30: p. A-1]

The LMI study provided the following synopsis of how NAVFAC Guide Specifications are developed:

"NAVFAC develops and maintains its specifications at its six Engineering Field Divisions (EFD's). Direction and coordination is enhanced by the limited number of EFD's and the positioning of a criteria manager at each EFD to maintain close ties with the NAVFAC headquarters criteria manager. Specifications are developed and maintained by NAVFAC project specification personnel or infrequently through contracts with industry." [Ref. 30: p. A-1]

2. Maintenance of Guide Specifications

Construction Guide specifications are updated every 5 years or sooner if major technological advances occur. In order to determine how this is done, NAVFAC's Western Field Division (WESTDIV) was visited. The information in the paragraphs that follow was provided by personnel working in the WESTDIV organization.

The NAVFAC P-34 "Engineering and Design Criteria for Navy Facilities" lists 308 guide specifications developed by NAVFAC. Responsibility for maintaining these is shared by the six EFD's in NAVFAC. Each EFD has approximately 60 guide specifications to maintain. These are assigned to NAVFAC project specifications personnel within the EFD. They must be updated at least every 5 years and this process generally begins during the third year of the cycle.

The first step involved in updating the document is coordination. This is done by sending a letter to all the users of the document asking for their comments. A separate letter is sent to industry. The purpose of the letters is to obtain information regarding state of the art items and operational requirements which must be incorporated into the guide specification in order to satisfy the minimum functional requirements of Navy shore activities. The users are requested to divide their comments into "essential" and "suggested" categories.

Once all of the comments are received a draft is prepared and sent to the other EFD's, manufacturers, contractors, Architect & Engineering firms (A&E's), and various associations dealing with the product. An attempt is made to cover as large a cross section as possible. They are given 60 days to review the draft. Thirty days slack is allowed for late responses so that the actual time for responses is 90 days. The reviewers comments are answered so that they will know how their comments were used or why they were not used.

The document is revised based on the comments received that are considered applicable to the needs of the Navy, and is then forwarded to NAVFAC for final review and approval. If many comments are received after the first coordination cycle, the document may go through another cycle before it is sent to NAVFAC.

The process may be delayed when there are budget cutbacks for criteria development. When this happens, an EFD may have to ask NAVFAC to assign responsibility for updating a guide specification to another EFD. [Ref. 15]

During the visit to CESO, the possibility of having CESO specification writers update guide specifications was discussed. Since CESO has trained specification writers and since they also have private firms available that are capable of doing this work, it seemed feasible that when an EFD was unable to update a guide specification that CESO could be tasked to do so. CESO representatives did not feel that this should be done on a large scale basis because they believed the architects and engineers had a better feel for what should be contained in a guide specification than would the CESO specification writers. Management within the WESTDIV EFD agreed with CESO and explained that because the architects and engineers within The EFD work with the projects all year long they are more familiar with the problems in the guide specification than would be a CESO specification writer.

In some cases, problems occur at on EFD with a guide specification maintained by another EFD. In such cases, a pen and ink change is made to the document without waiting for the EFD with the responsibility for maintaining the guide specification to make the formal change. As an example, due to strict EPA restrictions in California on volatile organic compounds, WESTDIV was required to amend the Painting Guide Specification which is maintained by the Atlantic Division (LANTDIV). Since the restrictions may not be as severe in other jurisdictions as they are in California, LANTDIV may decide that the document does not need to be amended. If this occurs, WESTDIV would publish an amended version of the guide specification for its use. The standard guide specification published by LANTDIV for painting would be known as NFGS-09910. WESTDIV's version, known as a "regional" guide specification would be known as NFGS-09910W, where W indicates that the document is unique to WESTDIV. [Ref. 15]

As a final note, if it is determined that a complete rewriting of the guide specification is not required, the COE and NAVFAC issue notices and amendment, respectively, to cover minor revisions that do not necessitate a complete rewriting of the guide specification. [Ref. 30: p. A-5]

The LMI study provided the following information regarding MASTERSPEC and SPECTEXT:

"MASTERSPEC and SPECTEXT are reviewed and revised, if necessary, on a three year cycle. Major changes to the specifications are made immediately. All changes are issued as a complete specification update and not as a notice or amendment." [Ref. 30: p. A-5,6]

It was curious to note that the LMI study listed low average specification ages for the COE and NAVFAC guide specifications. The LMI study recorded these ages as:

- Corp of Engineers - 1.7 years
- NAVFAC - 3.6 years
- MASTERSPEC - 2.0 years
- SPECTEXT - 1.9 years

Representatives from WESTDIV felt that these averages were too low since updating doesn't begin until year 3 and the process takes a full year to complete. The COE average is especially difficult to explain. The LMI study did not attempt to establish the cause for this deviation. [Ref. 30: p. A-6] [Ref. 15]

3. Specification Format

The LMI study provided the following description of the format used for guide specifications:

"The three-part format is a technique for organizing the content of each specification. In the three-part format, the first portion of the specification is devoted to general information such as references, etc.; the second portion details the material requirements for an item or the area being addressed; and the final portion covers the execution of the work. In most cases, the execution portion covers installation requirements, but it could cover processes or procedures. The three-part format has been widely accepted by all guide specification users and is being adopted by the COE and NAVFAC as they write and revise their specifications.

The guide specification systems all follow the CSI 16-division format. This criterion is jointly sponsored by CSI and the Construction Specifications Canada (CSC) and is accepted as an industry standard in both countries. This format provides a uniform approach to the organization of construction criteria. Division 1 contains general contract requirements, and Divisions 2 through 16 contain requirements for specific technical areas. Each division is further subdivided to facilitate the retrieval and identification of a specific section. For example, waterproofing is designated as 07100, a subdivision of Division 7,

Thermal and Moisture Protection. In the same manner, each subdivision can be further subdivided into smaller sections as necessary. Except for SPECTEXT, no system follows the designated CSI subdivision identification scheme exactly. The COE and NAVFAC utilize a numeric system to categorize all specifications except the older ones; SPECTEXT and GSA use an alphanumeric system' and MASTERSPEC does not use any numbering system beyond the major specification section identification.. The differences in specification numbering and organization that exist in the various systems are minor and are not major inhibitors of the comparison.

All guide specification systems use technical notes to clarify and advise the specification writer when there are wording choices to make. These notes also provide insight into the reference specification's intended use. The COE and NAVFAC put technical notes at the end of the specifications, and they are cross-referenced to the main body of the specification through capital letters located in the right-hand margin of the specification. MASTERSPEC provides the technical notes throughout the body of the specification. This system requires more editing than the DOD systems and can be cumbersome for the specification writer. SPECTEXT puts its technical notes in a technical aid series that complements each specification. Another difference is in the use of design aids or technical manuals. The COE and NAVFAC provide design aid through technical manuals, engineering pamphlets, etc., while MASTERSPEC and GSA provide green evaluation sheets at the end of each specification. These evaluation sheets provide the designer and specification writer with a narrative on the particular guide specification, but it is generally much less detailed than the DOD-provided design aids. These differences in organization can have a major impact on the effectiveness of the specification system." [Ref. 30: p. A-2,4,5]

Other differences between the military and commercial specifications were described in the LMI study as follows:

"Not all guide specification systems utilize non-proprietary or generic specifications. The Military Services use specifications that are almost exclusively non-proprietary and rely on detailed technical descriptions to describe the product. MASTERSPEC uses proprietary names to a large extent, which enables them to eliminate a significant amount of wording in specifying the desired product. In the GSA version of MASTERSPEC, the proprietary names have been removed and a lower level of detail exists in the GSA technical descriptions than in those of DOD specifications. SPECTEXT does not specify proprietary products but makes provisions to insert them in lieu of detailed descriptions. DOD use of and subsequent compliance with Federal Acquisition Regulations (FARs) require non-proprietary specifications with sufficiently detailed technical descriptions to permit free and open competition. Not all existing commercial specification systems meet these requirements." [Ref. 30]

E. DESIGN MANUALS

1. Description of Design Manuals

The Army, Navy and the Air Force develop manuals which are used by architects and engineers as a reference to assist them in designing construction projects. The Army, Navy, and Air Force refer to these manuals as Technical Manuals (TM's), Design Manuals (DM's), and Air Force Manuals (AFM's) respectively. In many cases, they will all use the same manual and refer to it as either a TM, DM or AFM. For example, the manual on "Masonry Structural Design for Buildings" is used by all three but is known to the Army as TM 5-808-3, by the Navy as NAVFAC DM-2.9, and by the Air Force as AFM 88-3, Chap. 3.

The Navy, as well as the other services, has many other design manuals that address issues other than construction. Design Manuals 1-5 discuss building construction exclusively. They serve the same purpose that building codes serve in private construction. They are a reference that lists design requirements for various types of building construction in the Navy. Building codes however, provide for the "minimum" requirements to provide for a safe facility. The design manuals generally provide the same type of information but where the minimum is not considered adequate for the Navy's use, this standard is increased. The building code remains the base however from which all design manuals begin. The Uniform Building Code (UBC) published by ICBO is the building code which has been selected as the base for the Navy. [Ref. 15]

2. Development of Design Manuals

There is some criticism regarding the design manuals in that much of the material is believed to be unnecessary. One individual went so far as to call them an "insult to a design professionals training and education". He felt, for example, that it was unnecessary to explain to an engineer how to calculate the load on a beam since any design professional would know how to do this. [Ref. 2] A representative from WESTDIV concurred with this by stating that:

"Design Manuals should be written for a professional engineer and not on an academic level. Many of the DM's include examples of problems which are available from other sources known to the designers thus these could be deleted."
[Ref. 15]

DM's are prepared by Architect and Engineering firms (A&E's) based on guidance provided by the architect or engineer in the EFD assigned to administer the

contract. The DM is coordinated much the same way that a guide specification is coordinated.

A representative from WESTDIV had this to say about the DM's:

"The content or style of the DM will probably reflect the personality of the administrator since he provides the guidance to the A&E. The result is that the length of a DM may change radically from one revision to the next. It also depends on the A&E. Some may agree with the DM and its contents and simply make minor modifications to it. Others may rewrite the entire manual." [Ref. 15]

The NAVFAC Design Manuals are in the process of being converted to Military Handbooks so that wider and more expedient distribution can take place. [Ref. 31]

F. A COMPARISON OF GUIDE SPECS, DM'S AND THE UBC

For illustrative purposes, a comparison was made between the Design Manual, the Guide specification, and the Uniform Building Code (UBC) for Masonry. Content and method of presentation of each publication were noted and compared.

1. Design Manual

As noted previously, the manual titled "Masonry Structural Design for Buildings" was used by the Army, Navy, and the Air Force. The manual is 44 pages long and contains the following chapters:

- Architectural and General Considerations
- Crack Control for Masonry Walls
- Structural Design for Concrete Masonry
- Structural Design of Brick Masonry
- Cavity Walls
- Composite Walls
- Shear Walls and Bearing Walls
- Lintels
- High Strength Mortars and Prefabrication
- Structural Design of Hollow Clay Tile Walls

The manual gives design examples and design aids in the Appendix for Concrete Masonry, Brick Walls, Cavity Walls, Composite Walls, Shear Walls and Beam Walls, and for Lintels. The Appendix also lists references to other government and non-government publications dealing with masonry. Architectural Detail Drawings are also provided in the Appendix.

A list of tables in the table of contents refers the reader to 47 different tables in the manual dealing with properties, allowable stresses, and sizes of the various types of masonry. Twentyeight figures give various examples, methods, symbols and nomenclature, ratios and dimensions of types of masonry construction. Lastly, an additional 174 figures deal with design curves of types of mortar for varying sizes of masonry units under a variety of conditions that consider winds, whether the wall is interior or exterior, load or non--load bearing and a various other conditions.

The manual prescribes the criteria and furnishes guidance for the structural design of masonry in military buildings. Applicable building codes and exceptions thereto are noted in the manual. Designs are based upon the engineered design concept in which walls and columns are analyzed on a stress basis which the manual considered a refinement of commonly used empirical methods. Structural systems covered in the manual are non-reinforced walls, partially reinforced walls, shear walls and load-bearing designs.

2. Guide Specification

The guide specification was titled Unit Masonry and is referred to as NFGS 04200. It is divided into 3 sections titled General, Products, and Execution. The general section lists 25 ASTM standards that are referenced in the guide specification and describes the submittals that a contractor should be required to submit. It also describes delivery and storage requirements and the final subsection prescribes procedures which are to be followed under a variety of environmental conditions.

The second section, which deals with Products, makes numerous references to ASTM standards but then proceeds to specify various types and grades of brick or masonry units to be used in various situations. In general, the ASTM standard describes the standard to which the product must conform and the guide specification specifies under which circumstances to use the product. The specification includes enough descriptive material so that the document can be useful to an inspector or contractor without having to refer extensively to the referenced ASTM standards. All a contractor or inspector would have to do is insure that the product was produced in accordance with the applicable standard. The standard to which a product is constructed is generally included in a products descriptive literature thus a contractor can satisfy the contract requirements by purchasing a product that complies with the ASTM standard referenced in the contract without ever having read the product standard itself.

The final section, Part 3, deals with Execution. It describes certain procedures necessary to obtain the final product. In many case,m there are no national standards for these procedures since in industry, when someone contracts for a project, he does so with a contractor that is generally a proven performer. It's understood that he knows how to perform common procedures as mixing mortar and laying block. But the government will not know beforehand who they will be contracting with because they are required to contract with the lowest bidder in a competitive process. Thus, the guide specification must describe how to perform these operations in detail so that a contractor will know what is expected of him.

The specification is concluded by two sections, one on General notes and another on Technical notes. The general notes state that the guide specification can not be referenced in a project specification but is to be used as a manuscript in preparing project specifications only. The notes explain that the guide specification may be edited and modified in any way to meet project requirements. They also caution that coordination of the sections and drawings should be make to insure that complete and operable systems and equipment are provided.

The final section lists Technical Notes. These are notes that elaborate on the first three sections. The notes are labelled by capital letters and are listed on the right hand column of the first three sections. For example, in Section 2, a capital letter D appears in parenthesis in the right hand column of the subsection on Building Bricks. Technical Note D gives further guidance regarding the dimensions for larger units of building bricks such as utility brick.

3. Uniform Building Code

Lastly, the section of the UBC dealing with Masonry was analyzed. The section is titled Chapter 24 "Masonry" and is 37 pages long. The scope of the chapter concerns material, design, construction, and quality control of masonry. It opens with two pages of definitions and then lists two more pages of notations which are to be used later in the chapter for design calculations.

Material Standards are then listed. The standards of Quality for the various materials used in masonry construction are also listed. For example, concrete masonry units shall comply with UBC Standard No. 24-3 which discusses quality control of concrete building brick. All of the UBC Standards referenced in this section are listed in Part XI of the UBC. The chapters refer to the standards as UBC Standards. ICBO, the developer of the UBC, does not actually develop these standards, they simply adopt

nationally recognized standards. The actual title of the UBC Standard referenced in the chapter can be found in Part XI of the UBC along with the source for the document. When standards don't exist, a specific requirement is spelled out as in the case of metal ties and anchors. These, for example, must have a minimum tensile strength of 30,000 psi.

The next section gives requirements for mortar and grout and specifies the mixtures and proportions of the various products that are to be used. After this there is a section that describes the actual construction requirements for materials handling, storage and preparation, special cold weather construction instructions and other conditions. A section on Quality Control follows which specifies tests to be performed.

The remainder of the chapter deals with the actual design of the various elements that go into masonry construction. Formulas to calculate a variety of stresses, forces and loads are provided and the chapter concludes with 10 tables designed to guide a builder or a designer in proper proportions of product mixes and also in the proper size of materials for various stresses and loads encountered in various types of construction.

4. Comparison

In summary, the building code combines aspects of the design manual and the guide specification. The UBC includes, in the latter part of the chapter, design calculations and requirements for many types of construction, although it does not carry out the calculations and descriptions to the degree of detail of the DM. The UBC also discusses many of the same things discussed in the guide specification regarding the products to be used in various circumstances. The formats are notably different since the guide specification is patterned after the CSI format which allows project specifications to be developed easily from them. The guide specification also goes into somewhat more detail in explaining the standards that are to be met. The UBC simply references the applicable UBC standard where there is one. The guide specification in almost every instance provides a brief description or additional requirement following every ASTM standard referenced. The guide specification, although longer, is therefore probably more useful as a single document to a contractor or an inspector since he can rely more on the guide specification alone without having to refer continuously to the various standards referenced in the document. The execution portion of the guide specification is more elaborate than the similar section of the UBC. The guide specification discusses workmanship more than the UBC but

this is probably so because the military must award contracts to the lowest bidder. As indicated before, the military cannot choose its contractors as industry does, thus its' guide specifications must carefully spell out elements of construction which would not be a concern to a private industry contracting with a reputable builder.

A representative of WESTDIV indicated that the guide specifications are more broad scoped than the building codes. For example, a guide specification may say to install a light fixture in accordance with the NEC that conforms to UL standards, and that it be tested to insure that it operates properly and safely. A light fixture installed in private practice will specify a specific model of light (proprietary data) and require it to be installed in accordance with applicable building codes and require that the end product be complete and useable. The building official will approve the light based on its intended purpose, will ask that it have a UL label on it and will test it for proper and safe operation. The point is that both result in a suitable light but the method followed in private practice is *not as enforceable* from a contracting standpoint as is the governments method. [Ref. 15]

As a final comparison, the Design Manuals are used to design the project which includes laying out the building on to drawings. The design section of the building code also serve this purpose. The guide specifications are used to develop project specifications which are contractable documents that describe the quality of the materials shown on the drawings and also how to install them. In this sense, the guide specifications support the design manuals. Although the building codes are not formatted in the same way as guide specifications they can still be used for contracting purposes. For example, a contract could conceivably be let that simply said, "Construct a 110' x 75' warehouse in accordance with the UBC" and a contractor could do so. As stated before however, *such a contract would not be as enforceable as one developed using a military guide specification.*

G. ADVERTISING AND DISTRIBUTION OF STANDARDS

Representatives of CESO provided the following input regarding how standards are advertised and distributed so that their use may be maximized.

1. Advertising Standards

A representative from CESO indicated that the committees advertise their standards in trade magazines, standards engineering society magazines, and through advertisements in a government magazine titled "Government Executive". Voluntary standards do not seem to be aimed at the federal government very much thus in this

regard the committees could do a better job of advertising their standards. CESO is always searching for potential users for standards and the coordination phase of updating a standard helps greatly in this regard. In order to keep the federal government more aware of voluntary standards being produced, NAVFAC is trying to set up a liaison group in Washington DC between industry and the government. The liaison group will be tasked with identifying key people in the services as points of contact for industry. In some cases a committee may contact the government when it discovers that there is a MILSPEC duplicating their standard. [Ref. 32]

2. Distribution of Standards

In the world of voluntary standards, ASTM and ANSI are the two primary providers of standards dealing with construction. Both publish catalogs that contain all of the standards that they control. These catalogs can be obtained simply by calling either organizations. In the case of ANSI, the catalog is broken up into sections listing its standards by subject and again by designation (source). Orders for standards are placed in accordance with instructions provided in the catalog.

NAVFAC's P-34 "Engineering and Design Criteria for Navy Facilities" lists all the voluntary standards referenced in the guide specification plus all the various standards, specifications, and drawings used in NAVFAC construction. It is assumed that the Army and Air Force have a similar publication. In the case of NAVFAC, the various standards are available through the Navy Publications and Printing Service Office. Many of the voluntary standards are also available through this office at a reduced rate. [Ref. 32]

In some cases it may be very difficult to obtain a publication. In one case experienced at CESO there was an excellent handbook for accesses for the handicapped that had been developed by the President's Special Commission for the Handicapped. It could not be ordered, however, because there was not a number on the handbook to refer to for ordering and stocking thus the Printing Office could not provide it. CESO was forced to use a handbook published by ANSI even though its graphics and print were inferior to the handbook developed by the President's special commission. [Ref. 31]

Another example of inadequate distribution concerned Residential Lighting fixtures. Once again, a good standard existed but it could not be ordered because the governing body had gone out of existence. CESO finally managed to obtain a few copies of the standard from the secretary of the old governing body and who was

storing them in her garage. After four years, CESO finally managed to convince the Institute of Electrical and Electronic Engineers (IEEE) to issue the standard as their own standard and to take over maintenance of the document. [Ref. 31]

H. SUMMARY

This chapter discussed the various types of standard that are used in construction. The standards discussed were voluntary standards. MIL and FED SPECS, building codes, guide specifications and technical or design related manuals.

Voluntary standards are produced by voluntary organizations that form committees comprised of users, manufacturers and special interest groups. These committees develop voluntary consensus standards that describe how to produce a product or perform some sort of procedure. MIL/FED SPECS do the same thing but are developed withing the military or federal services respectively.

Building codes were shown to be documents developed by model code organizations that reference product standards and describe where and when to use the various products. They also contain a section defining the design requirements which must be met for various types of construction. Guide specifications reference MIL/FED SPECS and voluntary standards and are used to develop project specifications which are contractable documents used in procuring military facilities. The private sector also develops guide specifications known as MASTERSPEC and SPECTEXT but these allow reference to proprietary data whereas military guide specifications cannot do this. Just as building codes, guide specifications tell where and when to use the various product standards.

Design manuals take the place of building codes in the Navy. Similar documents known as Technical manuals and Air Force manuals re used in the Army and the Air Force respectively. These manuals use the Uniform Building Code as their base. The UBC is considered to the minimally acceptable level for providing a safe facility. The design manuals increase the levels listed in the UBC where the level is considered inadequate for the military environment.

The processes involved in developing and maintaining the various standards documents were discussed. In all cases coordination was shown to be a key element in order to gain the largest degree of acceptance of a document as possible.

A comparison of the Design manuals, Guide specifications and the UBC demonstrated that there were similarities between the three. The UBC is a design manual but it also describes when to use product standards just as the guide

specification does. A key difference is that a guide specification is published in 3 section CSI format and product specifications developed from it are considered to be more enforceable from a contracting standpoint than product specifications that reference the UBC.

Lastly, advertising and distribution of standards was discussed. It was indicated that both industry and government could do a better job in advertising their standards, but that since NAVFAC is attempting to develop liaison between them, these functions will likely improve in the future.

IV. OUTCOMES AND FINDINGS

During the study, particular emphasis was placed on addressing the issues of coordination, duplication, and economics. The study was originally undertaken to determine if economics, or more specifically, the costs and benefits to producers, distributors, builders, and consumers are considered during the development of standards. It became apparent after only a few phone calls to individuals involved in writing standards that any discussion concerning standardization could not limit itself to economics exclusively because interwoven into the economics issue are equally demanding issues concerning coordination and duplication. Coordination is important because a standard written in such a way that satisfies one interest group will probably not satisfy the other groups. Duplication refers to those cases where the government and industry are writing standards for the same product or procedure. When this occurs, resources are being wasted. Both of these have an effect on the overall economic benefit of a standard.

Standards, in and of themselves provide an economic benefit. David Hemenway in his book "Industrywide Voluntary Product Standards" addresses, among other points, the economy of scale benefits that accrue through standardization. Essentially, the book points out that "as products become more uniform, alternative sources of supply increase, the markets widen, competition is encouraged, which forces producers to be more efficient, and ultimately price is driven down." [Ref. 33: p. 21]

R.B. Toth in his book "The Economics of Standardization" lists the following as benefits of standardization:

- Improves efficiency in design, development, material acquisition;
- Conserves money, manpower, time, facilities, natural resources;
- Enhances interchangeability, reliability, safety, maintainability. [Ref. 34: p. 17]

In addition, if a standard is a consensus standard, then theoretically the producers, users, and special interest groups have agreed on the level of the standard. *Agreement on a level does not imply that the level is optimal however. Only if life cycle cost and benefits for all affected parties are considered during the development of a standard can a standard be written at a level that approaches optimal.*

A problem results however, because the benefits are much more difficult to quantify than are the costs. R.B. Toth points this out when he quotes many managers as saying:

"The calculation of direct benefits is not possible because of the wide dispersion of benefits as well as the large portion of these benefits that are intangible."
[Ref. 34: p. iii]

An excellent example of a intangible benefit was provided by a representative of CESO who had just purchased a new home. He explained that he had just moved out of his old home that was 18 years old and had been built according to code. When his son took a shower in the evening, the noise created by water flowing through the narrow pipes was so loud that he was forced to turn the volume control on the television up so that he could hear it. His new home is custom built and has oversized copper pipes. There is no noise in the pipes when the water surges through and there is constant water pressure from the plumbing fixtures even if they are all operated simultaneously. [Ref. 10]

For this particular homeowner, this is an obvious benefit, but it is an intangible one. Thus, for the purposes of those standards writing organizations that decide to attempt such an analysis for the first time, it is recommended that they emphasize life cycle costs and those benefits that can be easily quantified. When they become more proficient at doing such an analysis, they may consider a more complete analysis that considers other benefits as well such as appearance, comfort, and aesthetic factors.

The original intent of this study was to determine if "life cycle costing" was used in developing building codes. It is not, but it was learned that although the building codes set a standard for the construction industry, they do not develop their own product standards. Instead, they refer to product standards which have been around for a long time and which are developed by committees that are completely independent from the model code organizations.

A. ECONOMICS OF STANDARDS IN CONSTRUCTION

The search began for a product standards committee that considered life cycle costing. Although all of the standards writers questioned indicated that costs were considered, none, with the exception of the developers of ASHRAE Standard 90.2P titled "Energy Efficient Design of New Low-Rise Residential Buildings", considered life cycle costing.

When questioned if economics were considered during the development of building codes, voluntary product standards, or MIL/FED SPECS, the following responses were received:

"Building codes and economics are not related. The building standards cannot be relied upon to give you a product that is economical. The standards do not show any indication of life cycle costs considerations." [Ref. 35]

"The National Bureau of Standards (NBS) has developed computer software programs which are capable of analyzing life cycle costs of standards. This is not being done by the standards writing organizations however." [Ref. 36]

"When reviewing changes to the standards, the committees don't look at them from a technical standpoint but rather look for consensus." [Ref. 37]

"The NBS found that smaller pipe could be used for water supply lines and drains and that vents could be made smaller and still function adequately. The benefit of this change to the consumer is that the cost of a home can be reduced by \$500.00." [Ref. 11]

"The building codes don't address a higher standard or the idea of quality. There really is no reason to do this. A higher level of standard has to do with maintenance, that is, the military may desire a more durable or higher quality item in order to reduce maintenance costs. If such requirements were placed in building codes than it would become necessary to talk in terms of the various levels of construction. These items are better addressed in a specification just as any owner would do. The code provides for a level of life and safety. Other areas that go beyond this life and safety aspect of the code should be addressed in a separate specification." [Ref. 11]

"The performance level of the code is developed by a consensus vote of the building officials who are legally constituted officials of the cities. Building officials are the individuals that look out for the public's welfare. By voting on what changes to adopt to the code, they are essentially representing the public." [Ref. 12]

"Building officials represent the individual homeowners during the development of building codes. Before a change to the code is approved, the building officials consider the effect of the change on life safety and also whether the home owner can afford the change." [Ref. 13]

"Economic considerations are rarely addressed at NEMA due to the potential for antitrust violations and liability considerations. Because of antitrust legislation, NEMA companies involved in developing voluntary standards cannot get together and talk about the cost of products without violating antitrust

legislation. Regarding liability, a price cannot be tied to a safety requirement. For example, if a safety improvement to a transformer costs \$10,000.00 it would be turned down for cost reasons. The problem results when someone dies because the safety feature was not installed. Because the value of life is too difficult to determine and is such a sensitive subject, the cost is not tied directly to the NEMA standards. Of course costs are considered but they are not quantified. Costs are masked by safety considerations.

At one time NFPA tried to require NEMA to perform a Cost/Benefit analysis for all revisions. Due to the antitrust and liability concerns, NEMA refused to comply. NFPA eventually backed down. Although there is no overt consideration in the public process to cost, there may be an oblique mention. NEMA treats the cost side of standards writing like an angry rattlesnake.

ASTM can consider costs more directly and can afford to do cost/benefit analysis because, in general, they write more basic standards. There is an economic basis to standards in that costs are considered in reaching a consensus on voluntary standards but costs are rarely mentioned in public documents." [Ref. 38]

"There is a philosophical problem because safety is not a well defined concept and complete safety is not achievable. The standards writers at NFPA agree by consensus vote on an acceptable level of safety based on the risks involved. The more you're willing to spend, the less risk there will be and the higher the level of safety will be. The standards writers do not go through a rigorous cost/benefit analysis but they do make judgement calls.

The federal agencies involved in standards writing may have less regard for cost/benefit analysis and more regard for life safety. Because they are not as concerned as private companies with cost they may be more inclined to write a more stringent standard.

NFPA has developed a Systems Concept Committee in order to coordinate the aspects of safety. The fear is that it may cost more to do a cost/benefit analysis than to produce the product. The cost of performing a cost/benefit analysis is used by those who have no regard for safety as one more way to block good, needed requirements. Such individuals will concentrate on whether the analyses was properly presented and not on whether it was needed.

Costs and benefits are considered just by the way the standards are presented. Users, however, have an in built safety bias and they like to gold plate but are unwilling to pay for it.

In the construction industry, standards writers also receive pressure from organizations as the National Association of Homebuilders (NAH). The NAH has said that there is a crisis being caused by the cost of housing. They feel that affordable housing is more important than ultimate safety. They are willing to accept a lower standard of housing and try to influence the standards writing organizations in that direction so that the cost of housing can be kept within achievable limits for more people." [Ref. 39]

"Standards are not concerned with cost. A product is identified that will be used and then a standard is written that describes how it should perform. It lists requirements it must meet in order to meet the standard.

Consider a guide specification for wood windows. The best wood windows are manufactured by Pella. The guide specification cannot specify Pella by name but it can eliminate less desirable products by requiring a test for wind leakage that only the superior brands of wood windows can pass. Life cycle costing comes into play when the specification writer asks what the minimally acceptable level of air leakage is that the government can live with. The specification is written to satisfy that need. A minimum level of performance is set that can be obtained within a certain cost parameter. ASTM describes test methods to determine the amount of air leakage. They do not, however, set the standard of what the minimally acceptable amount of air leakage should be. It is the responsibility of the building code or the guide specification to specify the limit and the level of performance." [Ref. 40]

"Considering the economics of standards is a very difficult thing to do because no one has ever been able to pin down the value of life. Several studies have been done on this. One in particular was done by the NBS when they were considering a standard for ground fault circuit interrupters." [Ref. 16]

"The changes made to the plumbing standard which resulted in a study conducted by the NBS, will be incorporated into the next edition of the CABO 1 & 2 Family Dwellings building code. It is felt that these changes will result in a \$200.00 to \$500.00 savings per new home constructed. It's not certain if the life cycle costs will be more or less as a result of this change. For example, because the standard allows for the use of smaller drain pipes, plumbers bills may increase as the occurrence of pipe blockages increases." [Ref. 14]

"Regarding voluntary consensus standards, ASTM considers economics from a philosophical standpoint. In ASTM's Form and Style manual, given to members who develop ASTM standards, there is a paragraph discussing the use of economic analysis in developing standards. It states that the standards writers should address cost and subsequent use, optimum use of resources to achieve a specific service, and cost effectiveness where applicable. It is felt that the committees consider economics during their technical arguments." [Ref. 41]

"Government performance standards are written to a higher level because of the extended life of most public buildings." [Ref. 28]

"In building codes, costs are addressed more from a hypothetical standpoint." [Ref. 25]

"Regarding guidance for military specification writers, a new standard, Military Standard 970 will require cost/benefit studies before a standard is chosen. It will

require that a technical analysis and an economic analysis of the requirements be performed before a standard is chosen. Based on this analysis, the appropriate reference will be chosen to be used in a contract specification or in developing a new specification." [Ref. 42]

"Regarding economics, CESO does not consider economics directly when writing standards. They do however attempt to write a standard to the level that will meet the users requirement. Cost/benefit analysis is not done per se but CESO will in some cases point out to the user that the requirement they are requesting could be met with a less stringent and less costly standard." [Ref. 31]

"If two specifications are available for the same product or piece of equipment, the one with the lowest life cycle cost will be chosen." [Ref. 9]

"Some of the voluntary standards writing organizations consider economics during the development of standards. This occurs when the users are interested in the energy usage associated with food service equipment used in restaurants or by DOD. In such cases, the manufacturers developed a plate that was mounted on the equipment so that the users could determine what their annual energy usage would be." [Ref. 32]

The only standards writing organization encountered that actually uses life cycle costing to determine the level that the standard should be written at was the American Society for Heating, Refrigeration, Air Conditioning Engineers (ASHRAE). A representative from Owens Corning who is a member of the ASHRAE committee had this to say about ASHRAE Standard 90.2:

"This is an energy standard that is being developed based on economic analysis using the methodologies developed by the National Bureau of Standards. The committee is using marginal analysis by considering an upgraded component and determining the incremental benefit received from the upgrade.

This committee is forging new ground by considering the standard from a truly economic standpoint. This had become necessary because the standards were being criticized by the users who claimed that the current standard did not make sense.

The revised standard has already gone through 3 drafts and the fourth will be coming out soon. The standard was supposed to be updated by 1985 but because of the difficulty of the task undertaken by the committee we are 2 years late with the update. The questions and issues have really been pinned down though, and an update is close at hand.

As an example of how the economic analysis is taking place, consider ceiling insulation. The committee used a non-insulated ceiling as a base and then considered increasing levels of insulation, i.e. R-11, R-19, R-30, R-38 ratings,

where the higher the insulation ratings represent thicker insulation. The committee determined when R-11 could be justified and under what circumstances R-19 could be justified. The results of the analysis will be displayed in a tabular format so that the user will simply have to look up his location and read from a graph which lists the R-value standard for his location.

One of the first steps that the committee had to accomplish was to set economic parameters. The stringency level of the standards was addressed as a function of economics. They set out to develop a brand new model called the National Energy Model. The model was broken down into levels of economic parameters and criteria were set for changes in each element. The committee selected 73 cities which were considered to be typical cities for a particular region. Energy use and projected housing starts in each city were multiplied together to determine the projected energy use. Iterations based on the various levels of economic parameters followed and the analysis was repeated until projected energy use based on a national scale was developed into a National Energy Model. The standard will list separate criteria and graphs for single, multiple, and mobile homes.

The military considers themselves to be light years ahead of voluntary standards writing committees when it comes to performing economic analysis, because they have computer programs to do the analysis. The military goes into more detail than industry considers necessary. For example, ASHRAE uses national cost averages whereas the military will make local factor adjustments to these averages. There is a difference in the emphasis placed on precision and accuracy. The military is more inclined to be very precise in its estimates about the future price of fuel for example. Due to the uncertainty around these prices, industry on the other hand would be less concerned with such precision.

In the past, the trend has been to be narrow sighted regarding energy. The country is lined up for a disaster and national level emphasis is required to prevent it. The new ASHRAE standard will consider housing only, but housing is only a small slice of the total energy pie. National emphasis is needed in order to force the other energy users to perform similar economic analysis in order to avoid a national energy shortage.

The average homeowner will be receiving a definite benefit from this standard because the committee is using consumer economics to develop the standard. When the committee first sat down to develop the standard there was a debate regarding whether consumer or societal cost should be the basis for the analysis. It was decided that consumer cost would be the basis. Societal cost would have considered energy conservation and at what stage during the development of a community the next power plant would have to be built. Existing homes would have to subsidize the cost of the new plant. As a result, a standard using societal cost as its basis for analysis would have been much more stringent because the committee would have done everything in its power to prevent having to build that next power plant. Due to this stringency, the committee agreed to proceed with the study using consumer cost as the basis for the analysis." [Ref. 43]

A representative from NAVFAC's Western Engineering Field Division provided the following comments:

"The quality of the standards is considered to be adequate. If buildings are actually constructed to standard there will be minimal problems associated with them. The biggest problem is with the actual installation. Condominium roofs are a perfect example. An individual homeowner with a bad roof may not have much influence but a whole group of condominium owners can exert considerable influence through lawyers on builders and standards writing organizations. Poor construction practices as these are due either to ignorance or deliberate cost cutting practices which amount to fraud. In order to stop these practices, consumers have to organize in order to be heard, but that is difficult to do. Consumers are organizing more though with the increase in large scale production of condominiums.

In some cases, poor installation practices force changes to the code. For example, conduit is supposed to be run through beams through the middle third of the beam so that the structural integrity of the beam is not weakened. If the hole is drilled through the side of the beam, the load that can be supported by the beam is reduced considerably and a failure is more likely to occur. If such failures become a common enough occurrence the code writers may have to require a heavier beam to be used in order to maintain minimally acceptable levels of safety. Thus, in order to insure that a safe structure is constructed, safety takes priority over economics and the heavier beam becomes the standard." [Ref. 15]

Another representative from WESTDIV provided the following comments regarding the use of economics at NAVFAC:

"In NAVFAC, projects in excess of \$2 million must be value engineered. During a VE analysis, all of the engineering and architectural disciplines look at the project and brainstorm for ways to bring the costs down and still satisfy the functional requirements.

Value Engineering is done by the A&E's in accordance with NAVFAC's P-442 'Economic Analysis Handbook'. At the beginning of the analysis, a bar chart is made to show where the costs are concentrated. The VE study is directed to those areas where the costs are concentrated. Life cycle analysis is performed to see if the overall function of the facility can be improved. It is also very important to have ongoing discussions with the user and with the designer during the VE study.

Business decisions should be made more during the design phase of a project and risk analysis should receive more emphasis. As an example, consider a 10 story office building. Due to cost overruns the military decides to cut it down to 9 floors. Assuming that this represents a 14% increase in the cost per office, if this had been a private builder working with a 10% margin, a decision like this

would have destroyed his margin. Thus decisions should be analyzed more from a business standpoint." [Ref. 44]

From these statements it can be seen that life cycle costing is not being used by the vast majority of standards writers in both the government and industry. Even ASHRAE Standard 90.2, which was the only standard based on life cycle costing encountered during the study, has not been published yet. It will be interesting to see how this standard eventually turns out because it will be a consensus standard. As such, the committee members must ultimately agree on the level of the standard. Whether that level will be the same as the level generated by the life cycle cost analysis remains to be seen. In any case, the ASHRAE standard is a step in the right direction and it is recommended that all organizations involved in writing standards study this document to see if it has any applications that can be used to improve their standards.

The plumbing standard is an interesting one because it only considered the original investment cost. It may be that it was not possible to accurately estimate the life cycle costs in this case but in order for this change to have real validity, a follow up study should be accomplished to determine if plumbing bills increase due to the smaller pipes. If they do, then the new standard should be reassessed.

The military seems to be performing some economic analysis but this is not directed at the military or federal specifications. NAVFAC, the COE, and the Air Force Civil Engineers all stated that life cycle costing is the way they do business. These statements apply to projects however, and not to standards. The Value Engineering analysis used by NAVFAC is an example of this. The procedures for this analysis have been formalized but no such procedures exist for considering life cycle costs of standards.

The NBS has developed software which they believe can be used to analyze the life cycle costs of standards. The standards writing organizations should be made aware of this capability if they are not already and be encouraged to at least examine the software to see if it can be used to improve the technical analysis that is performed during development of a standard.

Regarding building codes, as many individuals pointed out, the primary purpose of building codes is to provide minimum standards to safeguard life or limb, health, property and public welfare. A representative from CABO indicated that to consider economics in building codes would mean to consider maintenance costs and that such an analysis was best left up to those that are preparing the project specification. This

is probably a fair statement. Since building codes reference product standards and simply specify where and when to use these standards, the economic analysis may be more beneficial if directed at the product standards and not at the building codes.

A representative from NFPA indicated that there are some who make it difficult for the committees to perform cost/benefit analysis because they concentrate on whether the study was conducted properly and not on trying to perform a useful analysis. Probably the only way to stop this from happening is if leaders in standards writing such as ASTM, NFPA, UL, and ANSI as a primary coordinator of standards, require that a technical Cost/Benefit analysis be performed before a standard is considered acceptable. Costs need to be looked at as something that can be controlled and not as an angry rattlesnake. Life cycle costing of a standard will give standards writing committees a level to compare the previous consensus standard to. This may serve the purpose of demonstrating to the users and special interests groups on the committees that certain producers on the committee are producing at costs that are not economical. If users can unite and strengthen their positions on the committees, they may be able to use the information provided by the analysis to force producers to agree to write the standard at the level suggested by the Cost/Benefit analysis. Apparently the military is taking this position in its new version of Military Standard 970 which will require that a Cost/Benefit analysis be performed before a standard is chosen. Of course, the military can incorporate such a requirement more easily than voluntary standards writers because MIL/FED SPECS do not have to be consensus standards.

A representative of the COE made a good point regarding test methods for air leakage when he said that such standards are written for the sole purpose of measuring the amount of air leakage and that building codes and guide specifications should specify the acceptable limit or level of performance of the various product standards. This brings up the major argument of those in the military for not using building codes. They say that since building codes are written at a level to provide for a minimally acceptable level of safety, that they are often inadequate for military use. However, a study performed by the Federal Construction Council (FCC) found that in the case of live loadings on various types of buildings that "there are more similarities than differences in the loadings specified". [Ref. 45: p. 2] Apparently, most of the differences were represented by relatively small percentages of the total square footage of buildings.

Economics enters into the picture however when the two documents specify two largely differing levels to satisfy safety requirements. For example, the study by the FCC stated that:

"The 100-psf uniform load specified by the Corp of Engineers for private car garages is twice the load specified by other agencies. Similarly, the Navy and the COE specify a higher uniform loading (80 psf) for large clerical offices than for private offices (50 psf), a distinction not made in other standards. Such differences deserve investigation to ensure that they reflect genuine requirements and not just ultraconservatism." [Ref. 45: p. 2]

Indeed, such differences must be addressed, because they strike at the heart of life cycle costing. Will the increased loading requirements reduce the risks of structural collapse sufficiently to justify the increased costs of construction? It's doubtful whether such an analysis was ever carried out. In fact, based on the comments, the minimally acceptable levels of safety specified by the building codes and the levels specified by the military services are not based on economics at all. As a representative from WESTDIV indicated, some of the levels in the building codes had to be increased because builders failed repeatedly to comply with the code. But this does not excuse the writers of the building codes and guide specifications from considering life cycle costs and risks as they determine the minimally acceptable levels. Adjustments to the code can still be made based on actual experiences that were not considered in the economic analysis.

Granted, the primary purpose for a building code is to specify the minimally acceptable levels for safety, but it is also an economic document as well since it impacts builders behavior. It is difficult for the building codes to specify optimum levels of construction however. That is not their intended purpose since they do not attempt to consider all of the economic elements involved in the cost and usage of a building because the uses and lives associated with similarly constructed buildings will differ significantly. For example, a owner of a business may only need a building for 5 years. When he writes his specification for the project he will consider the risks he wants to take and how fast he can depreciate the building and then develop the project within certain cost parameters based on all of these variables. The code will restrict the risks he may take however by specifying the minimally acceptable levels required to meet safety. *However, if some of these risks have not been considered properly, then the code may be written at the wrong level.* In the case of family housing, if a code could

legitimately be written at a lower level, then housing costs could be brought down and more people would be able to afford housing. In other cases, as in the plumbing change cited earlier, a reduction in the acceptable limit may result in higher overall costs to the homeowner over the life of the home, in which case the minimally acceptable level should be increased. Thus, although the primary purpose of the building code is to state minimally acceptable levels to meet safety, economic analysis could be used to make them a better document.

One benefit of the voluntary consensus process is that manufacturers of equipment are mounting plates on their equipment stating what the annual energy usage is. As users on the committees become more aware of the differences between these various types of equipment, the manufacturers will be forced to consider life cycle costs more and the users may even be successful in standardizing the minimally acceptable energy usage per year. This will be good for the users because then producers will be encouraged to seek technology improvements to exceed the standard. Of course, competition already forces manufacturers to seek technology improvements, but a standard for energy useage would put the lower quality producers at an even bigger disadvantage which isn't necessarily all bad since one of the purposes of a standard is to protect the interests of the users as well.

As pointed out in Chapter III, the building codes are critical documents because they represent the base from which design manuals and guide specifications in the military are written. Since they are such a critical document, the remainder of this section will be devoted to material published by the NBS that ties economics to the code change process. Recall that the basic argument provided by those interviewed against using economic analysis during the development of building codes was that the primary purpose of a code is to provide a minimally safe building and that economics was best considered in another medium such as project specifications. The NBS would apparently disagree because they have published two guides which address estimating the economic impacts of building codes. The first, titled "An Economic Analysis of Building Code Impacts: A Suggested Approach" was published in 1978. The second was published in 1981 and is titled "Estimating Economic Impacts of Building Codes". A condensed version of the second publication, titled "Estimating Benefits and Costs of Building Regulations: A Step by Step Guide" was analyzed to see if the suggested approach would have validity not only to building codes, but to guide specifications and design manuals as well.

1. Estimating Benefits and Costs of Building Regulations

The Step by Step Guide describes itself as a:

"how-to guide for building officials, elected officials, builders, architects, engineers, trade association members, and others involved in code change decisions who need to determine the cost effectiveness of such changes."
[Ref. 46: p. iv]

The handbook points out that economic analysis has its limitations and that it should be used as one of several inputs to the decision making process. It provides a series of worksheets that help the analyst to decide whether to delete, add, or modify a code requirement. It also helps to rank alternatives and choose the least costly way to produce the greatest benefit.

The guide is divided into seven major steps. They are:

1. Define the problem.
2. Estimate Impacts on Building Costs.
3. Estimate Impacts on Safety and Performance.
4. Compute Net Monetary Benefits.
5. Estimate Aggregate Impacts.
6. Perform a Sensitivity Analysis.
7. Write up the Results.

Defining the problem involves recording key information about the code change such as what kinds of occupancies, construction types or building parts will be affected. It looks at the original requirement and considers how the proposal changes will affect the design requirements.

Estimating impacts on building costs involves determining the impact of the change on construction costs, construction delays, and government services. It uses the existing code requirement as a baseline and considers the difference between the proposed change and the base. It allows for discounting for changes which are anticipated in the future by using present worth discount factors. This allows for the effects of inflation on construction costs and operation and maintenance costs to be considered. The affects that a code change may have on construction delays are also considered and finally the effects on government services such as fire protection, police protection and code administration are also considered.

Since building codes are ultimately concerned with building safety the step involving estimating the impacts on safety and performance must be considered very

carefully. The effects of the change on property damages, lives lost, and injuries due to building accidents are considered during this step.

For property losses, where possible, dollars should be used to measure the effects of a code change. The guide recommends that another unit be used besides dollars to measure the life safety effect since the value of a life is so controversial. To illustrate this controversy the 1978 guide, referred to earlier, considered the 1975 National Electric Code requirement for the use of Ground Fault Circuit Interrupters (GFCI). The 1975 study wrote as follows:

"Using sensitivity analysis, a range of estimates were made of how much it costs society to save one life from electric shock by means of the GFCI provision. The cost per life saved was estimated to be nearly \$4 million. Under the most optimistic set of assumptions the lower bound estimate is about \$2.5 to \$3 million. A more pessimistic set of assumptions place the cost per life saved at nearly \$7 million." [Ref. 47: p. 54]

Because the value of life is so controversial, the guide suggests reporting life safety effects in terms of the number of lives saved or injuries avoided. If the analyst prefers to specify lives lost and injuries in dollar terms the guide references several studies that estimated the dollar value of life safety that can be used as guides in performing such an analysis.

Once the unit of measurement is selected the analyst is directed to go through several steps which consider such things as the types of building accidents affected; how the probabilities of each of these events occurring will change as a result of the change; the dollar value of the various kinds of property losses; and finally how the changes will affect the number of fatalities and/or injuries and the expected life safety impacts over time.

Changes to the building code may also affect the performance or usefulness of a building. The guide directs the analyst to consider how the amount of useable space available for the buildings primary purpose will be affected; how a space is going to be used and what changes will have to be made to satisfy the code change; how the change will affect rehabilitation costs; if delays in occupancy will occur; how durability, efficiency and amenities of a building are affected; if the residual value of a building will change; and finally how particular groups such as the owner and users of a building will be affected.

The fourth step involving computing net monetary benefits guides the analyst through a worksheet that results in the net present value of net monetary benefits per unit. It considers the total effect on performance and on costs to derive the net monetary benefits of a proposed code change.

While estimating aggregate impact, the guide points out that a code change may have different effects on different types of buildings in which case aggregating may be necessary. In cases where a code change may result in net losses for some buildings and net benefits for others then aggregating is necessary. In cases where all buildings benefit or all have net losses, aggregating may not be necessary.

The handbook directs the analyst to fill out worksheets for each of type of impact such as net monetary benefits for various building types or the number of lives saved.

The sixth step requires that a sensitivity analysis be performed. The guide points out that a sensitivity analysis will guide the analyst to the estimates that need further refining. It also serves to increase general acceptance of the outcomes of the analysis by performing the analysis using a range of estimates in an area where there is disagreement among the decision makers. If significant changes don't occur, then the parties are more likely to accept the general conclusions of the analysis.

Once again, the analyst is guided through a series of worksheets to determine the revised outcomes based on altered values. The results show which variables were altered, how they were altered, and results using the original and altered values. The results of the sensitivity analysis may provide decisionmakers with more confidence in the results of an analysis. However, in some cases much uncertainty may be revealed about underlying data in which case the economic analysis would not be used as a reliable guide to making decisions.

The handbook considers one final type of analysis called breakeven analysis but points out that it can only be used when all impacts are given in dollar terms.

The seventh step involves writing up the results. The guide provides an example of a table which describes all important impact which highlight the most important effects of the code change, even if they could not be quantified. Key assumptions should be stated. Quantitative information such as net monetary benefits and lives saved should be listed. Qualitative impacts such as impacts on innovation and other areas that cannot be quantified would also be listed. Lastly, the guide suggests that areas of uncertainty be listed with their corresponding results.

Based on the analysis of this step by step guide, it would appear that this guide could be used by those involved in developing building codes and it seems that the general technique could be applied to voluntary consensus standards as well. It's obvious from the statements presented earlier that economic analysis is not used as a tool to aid decisionmakers in determining whether or not to adopt a code change proposal. The reason why this is so could not be clearly determined. There seems to be a feeling that the consensus process works well so why change it. A representative from CABO stated the following:

"At one point, the government was trying to tell ASTM and other national standards writing organizations how to go about consensus procedures. After 150,000 pages of testimony, it was finally determined that the consensus procedures in place were adequate and already working." [Ref. 11]

If this is indeed the feeling shared by standards writers in general then it will be difficult to convince them to use economic analysis. Some are afraid of economic analysis because of antitrust concerns or the "angry rattlesnake" syndrome. If this is the case, the analysis can be carried out in terms of lives saved rather than in terms of the dollar value of life. It is hoped that the ASHRAE standard on energy is successful so that the value of this economic analysis tool to decisionmakers can be demonstrated. Since there are two members from the NBS on the ASHRAE committee developing Standard 90.2, it is also hoped that, if this new energy standard is successful, that the NBS will circulate its guide books for performing economic analysis to as many building officials and standards writers as possible.

B. COORDINATION OF STANDARDS IN CONSTRUCTION

Coordination is a key element in achieving a consensus standard. Since standards have wider acceptability and use if they are a consensus standard it is in the best interest of the standards writing bodies to coordinate their standards with as many manufacturers, users and special interest groups as possible.

Voluntary consensus standard organizations do this by forming committees that represent the three primary interest groups who then agree on a standard that suits their needs. Once agreement or consensus is reached the standard is published.

The military operates a little differently but they still coordinate their standards. A representative from CESO explained their procedure for coordination as follows:

"DOD standards are consensus standards to a degree in that industry responses are solicited. DOD must however determine its requirements and its need and match industry capability with that requirement. The requirement will not be reduced to satisfy a portion of industry thus DOD specifications differ from non-government standards in a very significant way. Coordination is still a key factor in this development however. Once a statement of requirement is developed, industry is requested to explain what they have that will meet DOD's needs. They respond and are permitted to question the requirement. In some cases, industry is able to demonstrate that new technological developments will better satisfy the requirement. In such cases, the requirement can be amended to reflect this constructive criticism. Possible users in DOD who are buying the products are also solicited for their opinions and remarks. There is thus limited consensus in that DOD attempts to accommodate industry and the users." [Ref. 9]

1. Building Codes

There is a debate going on between the voluntary standards writers and the building code officials regarding coordination. A representative from NFPA stated that:

"There is a debate going on regarding the model building code process and whether they actually achieve consensus. They allow input from all sources but the voting is done strictly by the building officials. The criticism is that better representation is needed. The model building code organizations argue that the process would be corrupted by manufacturers who are only interested in selling their wares and users who don't want to pay for anything. The model code organizations feel that building officials have no such biases. Another criticism is that the building officials have no stake in the consequences. They operate under the philosophy that they know what is best for the private citizen and that the average person doesn't understand the building standards anyway. They want to protect you from yourself. The criticism of this is that if they do this then they had better have input from all parties concerned so that the level of risk is satisfactory to everyone." [Ref. 39]

This matter of level of risk created by a building code is a very important issue and deserves further mention. In the economic section of this chapter it was stated that "building officials consider the effect the code change will have on life safety and also whether the home owner can afford the change." [Ref. 13] If economic analysis is not carried out and if all parties affected do not have a voice in the input, then how can the building officials decide if building owners can afford the change or not. Without an economic analysis, they can not possibly know what the effects on life safety and cost or benefits are going to be as a result of a code change. If the building officials are to retain the sole right as voting members, then the technical committees

should insure that they are well represented and that they have the expertise available to perform an economic analysis. CABO's committee on 1 & 2 Family Dwellings is an example of a committee that is well represented by many interest groups but based on a conversation with a representative from CABO, economic analysis is not considered by this committee.

There was a concern that the building officials may not have the educational background necessary to consider economic analysis. This is not so however since according to a CABO official, approximately 50% of the building officials have architecture or engineering degrees. They also have technical support services available to them through the model code organizations and these services are always improving due to competition between the three model code organizations. The building officials technical backgrounds combined with the technical services available to them through the model code organizations should allow the building officials to make intelligent economic decisions if they are so inclined.

2. Voluntary Standards

With the big push underway by the military to adopt as many voluntary standards as possible in lieu of MIL/FED specifications, there was a concern that there may not be enough government participation on the voluntary committees. In order to determine to what extent the government participated in the voluntary standards writing process, several organizations were contacted. Their responses were as follows:

"There is government participation at the ANSI national conferences." [Ref. 48]

"The Army Corp of Engineers does participate. Military representatives are actually on the standards writing committees and are involved in determining the level of standards. Since government construction accounts for 17% of all building construction, the government has a vested interest in determining how the standards are written." [Ref. 40]

"CESO is actively involved in participating on non-government standards writing committees. In some cases, CESO actually drafts the document that the standards body adopts. Virtually everyone at CESO is involved in one or two of these committees." [Ref. 9]

"CESO is currently working with 47 different non-government standards writing organizations." [Ref. 31]

"There is not much government participation at the National conferences for building codes. However, since HUD has adopted a model code, it has

participated quite actively and has succeeded in having several of its proposed code changes adopted." [Ref. 11]

"CESO provided prioritized lists to ASTM of MILSPECS that they felt should be commercialized. The process has been very successful and has allowed CESO to reduce its number of MILSPECS from 950 to 650 since 1979." [Ref. 20]

"Committee meetings tend to be dominated by manufacturers and supplier attendance. These organizations fund their people to insure that they attend so that their voice will be heard. When such domination occurs, the committees are successful at deemphasizing inputs submitted by correspondence from other members not present at the meeting. This generally results in moving the level of the standard to lower levels in order to allow participation of lower level of standard production manufacturers.

In some cases, DOD will threaten to drop out of the process if standards which are very important to DOD are passed at a level too low to meet the needs of DOD. One such case has to do with concrete. Manufacturers are pushing to pass a standard that would allow the use of more limestone in concrete. DOD feels that this will make the concrete weaker. The manufacturers have not provided sufficient test results to demonstrate that the concrete will still be adequate for DOD's use. Until they do, DOD will not support such a change. If they pass the standard without this testing, DOD will drop its membership on the committee and go back to using a MILSPEC. Since OMB Circular A-119 is the result of manufacturers criticism of the government's lack of participation on these committees, it will not look good for the committees to lose government membership because it failed to address legitimate concerns of committee members. Thus, DOD has a small hammer it can use to force its legitimate concerns." [Ref. 20]

"CESO is spearheading the move toward adopting non-government standards. We send people to committees and DOD relies on CESO to convey the concerns of DOD regarding deficiencies in non-government standards." [Ref. 49]

Based on these comments it is evident that there is considerable participation by the government on voluntary consensus standard committees. It is also evident that there is virtually no government involvement in the building code process. It is felt that private industry and the government alike could benefit however, if the government did become involved in this process. The sophisticated computer software packages that the government possesses could be used by the model building code technical committees to perform economic analysis of the building codes. Since large portions of the government use the building codes as their base for design criteria, the government would benefit because their design criteria base would be more viable and justifiably adoptable if they were based on sound economic analysis.

This participation is sorely needed as indicated by a building official from Monterey county in California who stated:

"I am not aware of any consumer advocate at the building code national conferences. The manufacturers speak on behalf of themselves and for the consumer." [Ref. 25]

If this is really the case, then the consumer or those that use and receive benefit from the building codes need a more unbiased representative than the manufacturers.

C. DUPLICATION AMONG STANDARDS IN CONSTRUCTION

OMB Circular A-119 directs that the government do the following:

"Establish policy to be followed by executive branch agencies working with organizations that produce or coordinate voluntary standards for materials, product systems, services or practices and in adopting and using such standards in procurement activity." [Ref. 18]

From the comments presented earlier, it should be evident that the coordination efforts on the part of organizations like CESO are aimed at eliminating much of the duplication that exists between voluntary standards and MIL/FED SPECS. In order to determine to what extent this problem with duplication exists, several organizations were contacted. They responded as follows:

"ANSI sees that the Navy, Army and Air Force have their own specifications for the same thing and that they are in need of coordination." [Ref. 50]

"DOD is the best of all government departments in adopting ANSI standards. OSHA is adopting ANSI standards where they exist. ANSI has a Construction Standards Board which meets once a year to coordinate the activities of construction standards. A representative from OSD sits on this board as the DOD representative. The Department of Labor, HUD and GSA are other government agencies that sit on this board." [Ref. 37]

"CESO adopts commercial standards for the Navy in every case we can." [Ref. 21]

"One of the roles of the Federal Construction Council (FCC) is to standardize the structural engineering criteria of the Federal Construction Agencies. It has standing committees which strive to accomplish this but given the different needs of the various agencies, this is very difficult to do. It is difficult to agree on uniform standards unless an over-riding authority such as the President or Congress demanded it. It would be unlikely though, that less costly units would result from such a demand." [Ref. 11]

Recognizing that many of the MIL/FED SPECS duplicate existing voluntary standards, DOD had to come up with a plan to adopt voluntary standards wherever possible. For the construction side of DOD, CESO identified 3000 voluntary standards for adoption. As mentioned before 1000 of these have already been adopted and 300 MIL SPECS have been eliminated. A problem still remains regarding identifying duplication among the various guide specifications and design manuals used by the services. Responding to direction from Congress to develop a common data base, NAVFAC spearheaded an effort to develop such a base. the result is the Construction Criteria Base (CCB).

D. CONSTRUCTION CRITERIA BASE

The Construction Criteria Base (CCB) is a data base presently consisting of Army, Navy, and NASA guide specifications. It contains 150,000 pages of typewritten text which have been stored on a Compact Disk Read-Only-Memory (CD-ROM) disk which is a micro computer readable disc capable of holding up to 250,000 pages of data. NAVFAC initiated the program by obtaining the services of the National Institute of Building Sciences (NIBS) to develop a comprehensive synthesis of fully indexed, mass produced criteria "libraries" used by the federal agencies. [Ref. 51]

A representative from NAVFAC had this to say about the system:

"It was originally named AFEIS (Automated Facilities Engineers Information System) but when it came time to market the system, it was renamed the Construction Criteria Base (CCB). It stores all public domain material, federal engineering and design criteria from the Navy, Army and NASA guide specifications on a 600 megabyte Compact Disk Read-Only-Memory (CD-ROM) disc. Graphics should be added to the CCB by January 1988 and other federal agencies are currently providing their material so that it can be added to the base. The system will enable a user to view, copy, and manipulate over 250,000 pages of information.

The objective is concerned with 'criteria sharing' within the federal government, that is, eliminating Navy documents where we can and adopting other agencies documents wherever possible. The Navy has already adopted some Army and Air Force documents. The payoff will be in productivity increases as design times go down due to easier access to design criteria. This has been made possible by the computer which allows a user to rapidly sort through the data and select the part that applies.

The CCB subscription cost is \$500.00 a year and a reader can be purchased for a one time fee of \$700.00. Users will input their updated records to the National Institute of Building Sciences (NIBS) and quarterly updates of the CD-

ROM will be distributed to the users. The success of the system is due in large part to allowing the individual inputers to the base to share in the ownership of the system. NAVFAC provided the first million dollars to get the program moving but ownership and the costs of maintaining the system are now being shared by many agencies.

We are presently working with NIBS to include the voluntary standards into the base. There is a problem with this because royalties will have to be paid to the individual standards writing organizations since this is their major source of income. The plan is to have NAVFAC spend another \$1 million to get this phase of the program started." [Ref. 35]

A representative of NIBS had this to say about the CCB:

"The goal is to eventually have all federal criteria related to construction included in the CCB. The Veterans Administration and the Navy Design Manuals will be included next, followed by the COE Technical Manuals, and GSA, DOE, and Air Force publications related to construction.

The project is financially self supporting thus Congressional cutbacks will have no impact on the future progress of the project. The CD-ROM contains the full text of the documents and is data base indexed. This enables the user to perform full search and retrieval of over 250,000 pages of text by calling up a word or group of words.

The CD-ROM is presently going through its beta test phase on limited distribution to the COE and NAVFAC. Once all of the bugs are worked out, it will be distributed through professional societies on a wider scale." [Ref. 16]

During a visit to CESO a program analyst working for CESO demonstrated how the CCB operated. A primary use of the CCB is to develop project specifications from the guide specifications contained in the CCB. The system was explained as follows:

"A program named 'SPECS INTACT' converts a master document into a contractable document. For example, SPECS INTACT allows a user to pull desired portions from a NAVFAC guide specification for use in a Navy construction project specification. Each section within a data base is referred to as a Masters Text which refers to either a NAVFAC, Army COE or NASA guide specification. Each guide specification contains 16 divisions, each of which has many sections. The user can select sections from each division to be included in the project specification. The program works in conjunction with a word processing document called 'VOLKSWRITER 3' and another program called 'SUPERKEY' which allows several word processing functions to be performed by pressing one key. SPECS INTACT acts as a shell over VOLKSWRITER 3 and SUPERKEY and pulls them up as they are needed. All three systems, the CCB, VOLKSWRITER 3, and SUPERKEY are required in order to produce a printed document.

The goal of the CCB program is to have all of the services using the same format. The format selected for this purpose was developed by the Construction Specification Institute (CSI) which is the format currently used in Navy specifications. NAVFAC is working with NASA and other agencies so that their software will conform to Federal Construction Guide Specifications and CSI guidelines." [Ref. 52]

A representative from the Air Force Civil Engineers headquarters stated that:

"The services were forced by Congress to take some action to decrease the duplication that exists between the services. This is so because they have lost resources that are necessary to develop and maintain all of the different manuals that the services currently have. The CCB seems to be addressing this matter." [Ref. 53]

Indeed, the CCB is addressing this issue of duplication. It will eventually contain all of the construction criteria available from all of the federal agencies which previous to the CD-ROM could not be obtained from a single solution. With the CCB, the CD-ROM discs can be "mass produced" and easily distributed to users of the documents. Presently, different guide specification formats are being used by each agency. With the CCB, a "standard format for all Guide Specifications" can result and will permit "shared use and fewer documents". It currently takes approximately 6 months to get documents. With the CCB, a document can be "obtained in a week", and "quarterly updates" are provided as part of the annual subscription cost. Presently, it's virtually impossible to index all of the various documents and perform error checks. With the CCB, the micro computer enables a user to perform "full search access and retrieval of any word or phrase in 5 seconds". The cost to the government of maintaining a paper system are very high. The CCB will be a self supporting, industry-wide self improving, coordinated system". [Ref. 51]

The criteria enters the CCB from many organizations in many forms. NIBS will store this criteria on large magnetic tapes which will be used to mass produce the CD-ROM discs. The discs will be used in conjunction with a micro computer to develop project specifications. Once projects are completed, problems associated with the specifications will be identified and updated and new criteria will be sent to NIBS for coordination who will in turn distribute quarterly updates.

NIBS feels that the CCB will provide the following benefits:

"The CCB will improve systems management, information organization, input from advisory committees, update coordination, reformatting, full text indexing,

and system validation. Project specifications will be able to be produced faster and at lower cost and it is anticipated that 'learning curves' will be reduced. The projected results are that error sources will be eliminated, fewer expensive change orders to construction contracts will be necessary, design reviews will be facilitated, projects will be completed faster, and construction quality will be better. Criteria will improve since the CCB allows for better criteria coordination, more input to criteria revision, rapid adoption of applicable industry advances, better use of voluntary standards, and fewer, more widely used criteria." [Ref. 51]

It would appear that the CCB is the answer to many of the problems facing government agencies and the means to end much of the criticism regarding coordination and duplication. Of course, the CCB cannot guarantee that this will happen. The CCB may provide the means to coordinate the documents and to reduce duplication, but it cannot be done without support from the people who will be using the CCB. It appears that there is wide spread support for the system, however, as can be seen from the following comment:

"The Army COE intends to review specifications from other services contained in the CCB. When the time comes to update Army guide specifications, if another agency has a guide specification that satisfies our needs we will adopt theirs rather than update ours." [Ref. 40]

The American Consulting Engineer Council Research and Management Foundation (ACEC-RMF) is concerned with duplication among construction documents and has developed a program that lists 4000 construction related standards documents. The program is not marketable yet but when it is "a study will be made to see which documents duplicate each other". [Ref. 2] ACEC-RMF was not aware of the extent to which guide specifications for example are used jointly by several military services nor of the number of military specifications that have been eliminated since the 1979 issuance of OMB Circular A-119. The ACEC-RMF program will list a joint specification as two separate specifications if used by both the Army and the Navy. With the new direction put out by NAVFAC directing agencies to give credit to originators of documents, ACEC-RMF should be able to identify joint specifications more readily and thereby avoid double counting. The cost for this program is expected to be \$150.00. Thus cost is not prohibitive and although it only contains the titles of the documents, it may still be a useful tool for identifying areas of duplication not yet identified by the services.

The program analyst at CESO that demonstrated SPECS INTACT was asked to give her opinion regarding using the ACEC-RMF program. In response she stated the following:

"Once all of the guide specifications and standards from all of the various government agencies and voluntary standards writing organizations are added to the CCB, it will essentially provide the same information in a table called the 'Master Reference Table' which can be generated from the CCB. This table is capable of listing all of the references used in the entire data base which is essentially the same thing that ACEC-RMF will be marketing." [Ref. 52]

However, it will be a long time before the 4000 construction related standards listed on the ACEC-RMF program are added to the CCB. It's not even known for sure if the voluntary standards can be included to the CCB. So, until they are added, it is recommended that the ACEC-RMF data base be purchased by NAVFAC and the Army COE at a minimum to see if it can help them in identifying areas of duplication that they may inadvertently have overlooked.

It's interesting to note how the CCB is viewed by the various levels of government. A representative of CESO had this to say about the perception of the CCB at the various levels:

"To Congress the system is known as AFEIS or the Automated Engineering Facilities Information System. It is a facade to Congress so that the military can show that it is developing a uniform system for use throughout the military. The AFEIS is known as the CCB on the user level. The CD-ROM discs allow this base of information to move laterally across the government. The users of the CCB may not be aware of AFEIS. Because the Army and Navy use different formats for their specifications, the users will be inclined to say that the Army and Navy use two entirely different systems. The middle levels of government or the people working at the NAVFAC, CESO or the headquarters for the Army COE can see both levels. They know that entirely different specification formats exist but Congress is probably not aware of this. Congress sees AFEIS and they are inclined to believe that there is uniformity among the services. In a sense there is because both services are using the same information from AFEIS contained on the CD-ROM but the users may not be aware of this.

Thus, the middle levels are the key link between upper and lower levels of government. They are making every effort to make the services more uniform by eliminating duplication wherever possible. Currently, approximately 130 of 300 guide specifications are used jointly by Army and Navy. NAVFAC is presently working with the Army to develop a means of getting the Army to notify the Navy's Engineering Field Divisions (EFD's) of reference changes to the guide specifications. In this way, the guide specifications will show the current list of

references. This is important because there are over a hundred changes per day to the voluntary standards and MIL/FED SPECS referenced by the guide specifications." [Ref. 49]

From these comments, it is evident that much is taking place to insure that there is uniformity among the services. Once all of the government services begin using the same format for their guide specifications and various other construction related documents, there truly will be uniformity in both content and in style of presentation.

E. SUMMARY

Based on the telephone and personal interviews conducted, it was determined that there is virtually no economic analysis of a technical sort being performed by the voluntary consensus standards writing organizations and government agencies. It was recommended that when the new ASHRAE Standard 90.2 for energy is published that other standards writing bodies study this document closely to see if the techniques used by ASHRAE are transferable to other standards writing bodies. ASHRAE will provide a description of the technique they used to develop their standard in an appendix, thus a brief review of the appendix should make such a determination simpler to make.

It was determined that the building codes, guide specifications, and design manuals do not consider economics either. A step by step guide published by the National Bureau of Standards was described that would allow for economic analysis of building codes to take place. It is believed that with minor adjustments, the techniques outlined in the guide could also be used to analyze design manuals used in the government.

It should be noted that the Architect and Engineering (A&E) firms that do work for NAVFAC and the COE perform value engineering for military construction projects. This seems to be the extent to which technical economic analysis is carried out however.

All of the standards writing bodies should be cautioned not to fall into the trap of simply reducing up-front costs as the revised plumbing standard seems to have done. Life cycle costs must be considered as well in order for a proper economic analysis to be carried out.

There seems to be good coordination between manufacturers, users, and special interest groups that develop voluntary product standards, and MIL/FED SPECS. It was noted that the level of consensus differs between the voluntary standards and the

MIL/FED SPECS but that the writers of MIL/FED SPECS will consider industry inputs and incorporate inputs if the overall need of the government can still be met.

The building codes were criticized because the building officials are the only ones that vote on changes to the code. It was concluded that by combining the technical backgrounds of the building officials with the technical services available to them through the model code organizations, the building officials could make intelligent economic decisions if they were so inclined. Equally important is the representation on the technical committees that provide recommendations to the building officials regarding the risk associated with proposed code changes. That is, if the building officials are going to continue being the only voting members then they should have input from all parties concerned so that the level of risk is satisfactory to everyone.

It was determined that there is government participation on voluntary standards committees but not on the model building code organizations. Although the government is not supposed to force its desires on the voluntary standards committees it can wield a small hammer by threatening to pull off the committees and resume use of MIL/FED SPECS if sound practices are not followed or if it is determined that manufacturers are dominating the procedures. It was noted that dominance by the manufacturers does occur in some cases because they make sure that they send their representatives to the committee meetings to insure that their voice is heard. As a result, they are often successful in deemphasizing concerns of users unable to attend the meetings.

OMB Circular A-119 directed the government to adopt and use voluntary standards in procurement activity. It was shown that organizations such as CESO are actively involved in this and that much of the duplication between voluntary standards and MIL/FED SPECS that was present in 1979 has been eliminated or has been identified and scheduled for action. The Construction Criteria Base (CCB) initiated by NAVFAC and developed and maintained by NIBS is a big step toward complying with the OMB Circular A-119 directive. Due to the ease with which data can be retrieved and manipulated, coordination of construction documents will be greatly enhanced. As a final comment, it was recommended that the computer program, soon to be marketed by ACEC Research and Management Foundation, be purchased by the military services to identify any duplication among construction documents that may have inadvertently been overlooked. Eventually the CCB may be able to serve the same purpose but until all construction criteria are added to the CCB, the ACEC-RMF

'Building Standards Data Base' could serve as a valuable tool to identify duplicities that have inadvertently been overlooked by the military.

V. CONCLUSION

This study was undertaken to determine how standards relating to construction are developed and to analyze to what extent economic analysis is used during their development.

In addition it set out to determine how much progress has been made toward meeting the directives and recommendations made by OMB Circular A-119 issued in 1979 and the Logistics Management Institute study conducted in 1985. OMB Circular A-119 established conditions for federal participation in voluntary standards work. The LMI study made recommendations for the military regarding coordination of their guide specifications and for using computers and word processors more for maintaining guide specifications.

A. SUMMARY

Before these issues were addressed, the organizations involved in developing standards were introduced. The American Society for Testing and Materials (ASTM) and the National Fire Protection Agency (NFPA) were described as major contributors of voluntary consensus product standards. It was explained that the American National Standards Institute (ANSI) does not develop its own standards but that they serve as a primary coordinator of standards. When the ANSI logo, "American National Standard" appears on a product standard that ANSI has coordinated, a user of that standard can be assured that the standard was developed in accordance with a set of strict guidelines published by ANSI. The most important aspect of these guidelines is that the standard be a consensus standard, meaning that at least three primary interest groups consisting of manufacturer, user, and special interest groups be represented on the committee assigned to develop the product standard. No single interest group is allowed to dominate and all concerns and comments must be given fair consideration. ASTM and NFPA also have similar guidelines which they provide to their committee members. ASTM publishes a few of their standards through ANSI but prefers to act as its own clearing house for the majority of its standards. ANSI serves as a clearing house for approximately 6000 standards provided by over 80 standards writing organizations who submit their standards voluntarily to ANSI for recognition as national consensus standards.

Under the Naval Facilities Engineering Command (NAVFAC) is the Civil Engineer Support Office (CESO) who serves as a major contributor of military specifications. They are also very involved in coordinating MIL/FED SPECS with voluntary product standards.

Three model code organizations were introduced. The Building Officials and Code Administrators International, Inc. (BOCA) develops the BOCA building code and serves the northern part of the U.S. The Southern Building Code Congress International, Inc. (SBCCI) develops the Standard Building Code (SBC) and serves the southern part of the U.S. The International Conference of Building Officials (ICBO) develop the Uniform Building Code (UBC) and serve the western part of the U.S. The UBC is the document which is used as the base from which military design and technical manuals are developed. The three model code organizations established the Council of American Building Officials (CABO) for the purpose of consolidating their efforts in those matters that are of mutual concern to them. CABO publishes the codes for 1 & 2 Family Dwellings and for Physically Handicapped Accesses.

The federal agencies that were considered during the course of this study that are involved in developing design guides and guide specifications related to construction are the U.S. Department of Energy (DOE), NAVFAC, the U.S. Army Corp of Engineers (COE), and the National Aeronautics and Space Administration (NASA).

Non-government organizations involved in developing guide specifications are the American Institute of Architects Service Corporation (AIA) and the Construction Specifications Institute (CSI).

The National Institute of Building Sciences (NIBS) and the American Consulting Engineer Council Research and Management Foundation (ACEC-RMF) were introduced as key players involved in coordinating the efforts of the various organizations.

Coordination was defined as the act of allowing anyone that is potentially interested in a standard the opportunity to comment on the acceptability of the standard. On the part of the federal government, coordination also involves adopting voluntary product standards in lieu of MIL/FED SPECS. CESO was shown to be actively involved in this process.

The voluntary standards and MIL/FED SPECS were described as "how to" types of documents that describe how to produce a product or how to perform a procedure.

Building codes reference nationally recognized product standards and describe "where and when" to use the product standards. They also contain a section defining the design requirements which must be met for various types of construction. Guide specifications reference voluntary standards and MIL/FED SPECS and are used to develop project specifications which are contractable documents used in procuring military facilities. The private sector also develops guide specifications known as MASTERSPEC (AIA's specification) and SPECTEXT (CSI's specification) but these allow reference to proprietary data whereas military guide specifications are not allowed to do this. Just like building codes, guide specifications tell where and when to use the various product standards.

Design manuals are used by the Navy in lieu of building codes because building codes are written at the minimally acceptable level to provide a safe facility. The design manuals increase these levels where the minimum levels are not considered adequate to meet the military's need.

The processes involved in developing and maintaining the various standards documents were discussed. In all cases, coordination was shown to be a key element in order to gain the largest degree of acceptance of a document as possible.

Regarding advertisement and distribution of standards, it was pointed out that both industry and government could do a better job with advertising their standards and that NAVFAC was taking steps to develop liaison between industry and government.

B. CONCLUSIONS

It appears that in the area of construction the recommendations made by OMB Circular A-119 and the LMI study have been taken to heart. The military, largely through the efforts of NAVFAC and its subordinate CESO, and the Army COE have adopted many product standards which allows for the cancellation of MIL/FED SPECS. Ceso has been instrumental in identifying voluntary standards for adoption and actively participates on these standards committees. This involvement has resulted in product standards being modified slightly so that they can be used as acquisition standards by the government.

LMI's recommendation *against* using commercial guide specifications in place of NAVFAC and COE guide specifications was made because commercially available specifications lack the precision needed in DOD's contracting and procurement environment and would require DOD to make extensive changes to the documents and

procedures supporting the military construction process. [Ref. 30: p. ii] This recommendation was supported by members of NAVFAC because of the way they do business, namely, by acquiring facilities through the competitive bid process. If a project specification is not precise in its instructions to a contractor, then numerous change orders will result which increase the price of the contract. In addition, commercial guide specifications allow reference to proprietary data which is strictly forbidden by Congress for military contracts since it is completely contrary to the competitive spirit under which military facilities are procured.

LMI's recommendation to coordinate the guide specifications is also underway. Many of the Army, Navy, and Air Force guide specifications are joint specifications, differentiated only by the cover sheet. It was pointed out that the recent direction by NAVFAC to give credit to the originator of a document on the front cover of the document will hopefully eliminate many of the criticisms that duplicity exists between these documents. NAVFAC and the COE have identified the duplicities in their guide specifications and design manuals and with the voluntary standards and are taking steps to correct them. It's a long, tedious process, being performed by a limited number of personnel. Documents are only updated every 5 years and the plan is to coordinate them as they become due for update. With the arrival of the Construction Criteria Base (CCB) this process will be greatly simplified. Thus within the next 5 years virtually all of the duplicity should be eliminated.

The process of coordination is complicated and lengthy, especially where adopting voluntary product standards is concerned. It is therefore recommended that the coordination of MIL/FED SPECS with voluntary standards be allowed to take place in accordance with the current 5 year update schedules. It is believed that the procedures and the system required for this to happen are in place and that outside pressures to speed the process up will only cause errors to be made. This is so since the coordination phase of the process would probably have to be reduced in order to meet constricted time lines. In addition proper coordination is crucial in order to gain wide acceptance of a document.

Where guide specifications are concerned, if rapid coordination of guide specifications is forced on the EFD's they will probably be unable to perform all of the updates due to limited personnel and financial resources which will probably force CESO to take on some of this responsibility. It was pointed out that CESO should probably not be updating guide specifications because they are not actively involved

with them and are therefore not as familiar with them as the engineers and architects at the EFD's are. In addition, if CESO took on this increased work load they would have less time to spend on adopting voluntary product standards. So, unless more people and money can be allocated to updating guide specifications, design manuals, and MIL/FED SPECS, it is recommended that the schedules in place to date remain the same.

The Construction Criteria Base (CCB), which has been placed on CD-ROM discs are the answer to LMI's last recommendation regarding computers and word processors. The CCB will enhance coordination and assist in eliminating duplicity among the documents included in the base. With its plan to include all federal construction criteria and hopefully voluntary product standards, the CCB will be a powerful tool which will allow updates and changes to the documents to be made rapidly. Having more current and precise information will reduce change orders which is a primary goal of all construction agencies. Lastly, the goal is to have all of the guide specifications written in CSI format, which will allow construction contractors to move easily between contracts advertised by different branches of the military.

A final area addressed during the study concerned economic analysis during the development of standards. It was concluded that economic analysis is not being used by the committees that develop consensus standards with one exception. The exception is ASHRAE Standard 90.2 regarding energy in residential housing. This standard has not been completed yet but is being based on consumer economics utilizing life cycle cost analysis techniques developed by the National Bureau of Standards (NBS). It is unknown whether the levels developed by the analysis will be used or if the levels will change significantly in order to reach consensus. The committee appears to be very concerned about developing a standard that will be of significant benefit to the users. One committee member expressed concern for the nation and indicated that he felt the nation was being lined up for a major energy shortage. He pointed out that the new ASHRAE Standard 90.2 would only cover residential housing and that committees responsible for developing standards for other types of buildings should produce standards based on economic analysis of life cycle costs also so that energy throughout the nation can be used more efficiently.

The statement was made that the "consensus" standard committees do not use economic analysis. There are apparently some other manufacturers in the building products industry that do consider life cycle costs though. During the eleventh hour of

this study, after all the research had been completed and the results were being written up, CSI sponsored a symposium in Monterey, California featuring manufacturers that develop specifications in CSI format. Sloan Valve Company, a manufacturer of bathroom products indicated they were not involved with the consensus process but that their products exceeded the levels developed by the standards. What is significant about this company, is that they will perform life cycle cost analysis for prospective customers in order to demonstrate that over the life of a building, thousands of dollars can be saved in water costs and plumbing repairs if their fixtures are used. They are able to do this because their toilets, for example, do not leak to the extent that other toilets do, and they employ advanced technology to flush 100% of the wastes through plumbing lines using only 1.5 gallons of water discharged at high pressures. They were critical of the ANSI standard for 1.5 gallon toilets which is a non-proprietary standard because they claimed that there are a lot of products on the market that meet the ANSI standard but do not operate efficiently. It is Sloan's intention to contact municipalities in the state and attempt to have their product become the standard through legislation. They feel this is important in areas such as California that are very water conservation oriented and that already have legislation passed requiring the use of 1.5 gallon toilets. If they can demonstrate that their product will save a municipality thousands of dollars over the life of a building, then it is likely that an amendment will be made to the local building code specifying a 'Sloan' toilet as the standard.

It was demonstrated that economic analysis is not being used in building codes or federal government design manuals either. A step by step guide developed by NBS demonstrates a method for doing this. It is recommended that the technical committees belonging to the model building code organizations begin using this guide or a guide similar to the NBS guide and require the A&E's to perform an economic analysis as part of the process involved in updating design manuals.

As a final point, building codes were described as documents that provide minimum standards to safeguard life or limb, health, property, and public welfare. Inherent in these codes are risks assumed by occupants of buildings constructed to these minimum standards. Since building officials are the only ones that vote on code changes they are essentially determining the level of risk that all users of the code will assume. The point was made that if the building officials are going to continue to be the only voting members, then the technical committees that make recommendations

to the building officials regarding proposed changes to the code had better have input from all parties concerned so that the level of risk is satisfactory to everyone.

LIST OF REFERENCES

1. Kuchnicki, Richard P., *Communicating Between Code Bodies and Standards Organizations*, ASTM Standardization News, June 1986
2. American Consulting Engineer Council Research and Management Foundation, Telephone Conversation, Washington, D.C., 4 SEP 87
3. American Society for Testing and Materials pamphlet, *20 Questions about ASTM*, ASTM, Philadelphia, PA.
4. American Society for Testing and Materials, *A Great Value by any Standard*, ASTM, Philadelphia, PA.
5. American Society for Testing and Materials, Telephone Conversation, ASTM, Philadelphia, PA., 18 AUG 87.
6. National Fire Protection Association, *NFPA Directory*, NFPA, Quincy, MA., 1987
7. American National Standards Institute pamphlet PR 18f, *Questions and Answers*, American National Standards Institute, ANSI, New York, NY., 1987
8. Civil Engineer Support Office, Interview Number 1, CESO, Port Hueneme, CA., 8 SEP 87.
9. Civil Engineer Support Office, Interview Number 2, CESO, Port Hueneme, CA., 8 SEP 87
10. Civil Engineer Support Office, Interview Number 5, CESO, Port Hueneme, CA., 10 SEP 87.
11. Council of American Building Officials, Telephone Conversation, CABO, Washington, D.C., 17 AUG 87.
12. International Conference of Building Officials, Telephone Conversation, ICBO, Whittier, CA., 31 JUL 87
13. Southern Building Code Congress International, Inc., Telephone Conversation, SBCCI, Birmingham, AL., 31 JUL 87.

14. International Conference of Building Officials, Telephone Conversation, ICBO, Whittier, CA., 1 SEP 87
15. NAVFAC Western Engineering Field Division, Interview Number 1, WESTDIV, San Bruno, CA., 8 OCT 87
16. National Institute of Building Sciences, Telephone Conversation, NIBS, Washington, D.C., 2 SEP 87.
17. American National Standards Institute, *Procedures for the Development and Coordination of American National Standards*, ANSI, New York, NY., April 1983
18. Sullivan, Charles P., *Standards and Standardization*, Marcel Dekker, Inc., 1983.
19. Civil Engineer Support Office, Document 1503b/0207b Topic I, *Preparing a New Specification or Standard*, CESO, Port Hueneme, CA., 16 SEP 1981.
20. Civil Engineer Support Office, Interview Number 3, CESO, Port Hueneme, CA., 8 SEP 1987.
21. Civil Engineer Support Office, Telephone Conversation, CESO, Port Hueneme, CA., 19 AUG 87.
22. Building Officials and Code Administrators International Pamphlet, *Building Codes - How do they help you?*, BOCA, Country Club Hills, IL.
23. International Conference of Building Officials, *Uniform Building Code*, ICBO, Whittier, CA., 1985
24. Building Officials and Code Administrators International, *Adoption of the BOCA/National Codes*, BOCA, Country Club Hills, IL.
25. Monterey County Building Official, Telephone Conversation, Monterey County, CA., 17 AUG 87
26. International Conference of Building Officials, Senior Plans Examiner, Telephone Conversation, ICBO, Whittier, CA., 14 AUG 87.
27. Monterey County Building Official Number 2, Telephone Conversation, Monterey County, CA., 17 AUG 87.
28. Monterey County Building Official Number 3, Telephone Conversation, Monterey County, CA., 12 AUG 87.
29. Naval Postgraduate School, Operations Research Department, Telephone Conversation, Monterey, CA., 21 AUG 1987.

30. Logistics Management Institute, *Changing the DOD Construction Guide Specifications*, LMI, Bethesda, MD., June 1985.
31. Civil Engineer Support Office, Interview Number 1, CESO, Port Hueneme, CA., 8 SEP 87.
32. Civil Engineer Support Office, Interview Number 4, CESO, Port Hueneme, CA., 9 SEP 87.
33. Hemenway, David, *Industrywide Voluntary Product Standards*, Ballinger Publishing Co., Cambridge, MA., 1975.
34. Toth, Robert B., *The Economics of Standardization*, Standards Engineering Society, Minneapolis, MN., 1984.
35. Naval Facilities Engineering Command, NAVFAC Headquarters, Telephone Conversation, NAVFAC, Alexandria, VA., 19 AUG 87.
36. National Bureau of Standards, Telephone Conversation, Industrial Economist, NBS, Washington D.C., 18 AUG 87.
37. American National Standards Institute, Telephone Conversation, ANSI Construction Activities Division, ANSI, New York, N.Y., 17 AUG 87.
38. National Electrical Manufacturers Association, Telephone Conversation, NEMA Assistant Manager of Engineering, 31 July 87.
39. National Fire Protection Association, Telephone Conversation, NFPA Assistant Vice President of Standards, NFPA, Quincy, MA., 10 AUG 87.
40. U.S. Army Corp of Engineers, Telephone Conversation, Headquarters Design Division, Washington D.C., 28 AUG 87.
41. American Society for Testing and Materials, Telephone Conversation, ASTM Systems, Products, and Materials Division, ASTM, Philadelphia, PA., 18 AUG 87..
42. Defense Standardization Program Office, Telephone Conversation, DSPO, Washington, D.C., 18 SEP 87.
43. Owens Corning, Telephone Conversation, Research Associate, PHD Mechanical Engineering, Grandville, OH., 1 SEP 87.
44. Naval Facilities Engineering Command, Western Engineering Field Division, Interview Number 2, WESTDIV, San Bruno, CA., 8 AUG 87.

45. Federal Construction Council Standing Committee on Civil and Structural Engineering, *Standardizing the Structural Engineering Criteria of Federal Construction Agencies*, Reprint from the Transaction of the FCC for 1979-80.
46. Rawie, Carol Chapman, U.S. Department of Commerce National Bureau of Standards, *Estimating Benefits and Costs of Building Regulations: A Step by Step Guide*, NBS Publication Number NBSIR-81-2223, June 1981.
47. McConnaughey Jr., John S., U.S. Department of Commerce, National Bureau of Standards, *An Economic Analysis of Building Code Impacts: A Suggested Approach*, NBS Publication Number NBSIR 78-1528, October 1978.
48. American National Standards Institute, Telephone Conversation, ANSI, New York, N.Y., 17 AUG 87.
49. Civil Engineer Support Office, Interview Number 7, CESO, Port Hueneme, CA., 10 SEP 87.
50. American National Standards Institute, Telephone Conversation, Vice President for DOD Government Relations, ANSI, New York, N.Y., 17 AUG 87.
51. National Institute of Building Sciences, *Construction Criteria Base*, NIBS, Washington, D.C., 1987.
52. Civil Engineer Support Office, Interview Number 6, CESO, Port Hueneme, CA., 10 SEP 87.
53. United States Air Force Civil Engineers, Telephone Conversation, Headquarters Design Department, Washington, D.C., 3 SEP 87.

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